OTS: 60-41,352

JPRS: 5540

10 September 1960

SOVIET NONFERROUS METALLURGY

No. 14

SELECTED TRANSLATIONS

Distributed by:

OFFICE OF TECHNICAL SERVICES
U. S. DEPARTMENT OF COMMERCE
WASHINGTON 25, D. C.

Price: ~~$2.25~~

U. S. JOINT PUBLICATIONS RESEARCH SERVICE
205 EAST 42nd STREET, SUITE 300
NEW YORK 17, N. Y.

JPRS: 5540

CSO: 3001-N/11

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Introduction

This is a serial publication containing selected translations on nonferrous metallurgy in the Soviet Union. This report consists of translations of Chapters II (pp. 16-19), V, VIII, and X, of the book entitled "Planning in Nonferrous Metallurgy."

CHAPTER II

The Raw Material Resources and Output Capacity of the Enterprise as the Basis for Planning Production

1. Raw Material (Ore) Resources

The material foundation of production in nonferrous metallurgy as the mining-metallurgical branch of industry are the ore reserves and production-technical possibilities of enterprises.

The scale of the production of nonferrous metals depends on the number and size of the active enterprises (ore mines, /concentrator/ plants, /metallurgical/ plants), but this technical base, in turn, depends on the concrete ore reserves at the disposal of this or that branch of nonferrous metallurgy.

In the Soviet Union the proven reserves of the ores of nonferrous metals are expressed in enormous figures, and consequently the development of the /Soviet/ nonferrous metallurgy is based on solid and fully reliable resources.

The largest enterprises of the copper and nickel industry are assured of actual reserves of ores for a period of more than 10 years in advance, and the existing bauxite deposits ensure the aluminum plants for more than 15-20 years. The USSR leads the world in its total reserves of lead.

The years of World War II witnessed the establishment of a reliable raw materials base for the tungsten and molybdenum industry.

It may be stated that the more we study our mineral wealth the fuller and more concrete is our knowledge of it and the greater is the amount of the proven reserves of the ores of all kinds of nonferrous and rare metals.

When drafting plans of output it is necessary to know the exact amount of raw material reserves at the disposal of this or that industrial enterprise or an active branch of industry as a whole.

The determination of reserves involves primarily the determination of the degree of exploration of a deposit. Reserves are classified in the following categories according to degree of exploration, accuracy of calculation, and reliability of determination:

A_1 -- reserves fit for the exact operative calculations of enterprises;

A_2 -- for output plans (assets justifying the recoupment of capital and production expenditures);

B -- for long-range plans of enterprises and planning organs;

C -- for general considerations -- compilation of long-range branch-of-industry plans, plans of geologic prospecting activities and geologic conclusions.

Only the reserves in the higher categories (A and B) can serve as a foundation for current production planning.

Of essential importance are not only the absolute figures of raw-material resources but also the characteristics of ores from the standpoint of the possibility of utilizing them at a given time. Seen from this viewpoint, the following groups of ore reserves are differentiated: geologic, balance-sheet and industrial reserves. The characteristics of each group are reduced to the following.

Geologic Reserves of mineral deposits: thus are termed all the reserves of deposits, individual sectors, and mine fields, that have been discovered as a result of conducted geologic-prospecting and mining activities, and calculated by special geologic organizations or by various administrative commissions (VKZ, RKZ).

Balance-Sheet Reserves: thus are termed those geologic reserves which from the standpoint of their quality characteristics and technical and economic indexes satisfy the requirements of industry. The reserves which cannot be utilized at a given stage of development of technology and economics are classified as extra-balance-sheet reserves.

Industrial Reserves of deposits are determined by deducting from the balance-sheet reserves the losses envisaged in the projects or plans of deposit exploitation.

During production planning the analysis of raw-material resources should show the extent to which the enterprise or the branch of industry is assured of adequate actual ore reserves.

The calculation of this adequacy is conducted by comparing the ore reserves with the scale of yearly extraction.

For this calculation the following formula is used:

$$t = \frac{Q \cdot 9}{P}$$

where t is period of acequacy of reserves, in years

- Q is balance-sheet reserves in the higher categories; (A +B), in tons
- q is index of extraction of ore from deposit;
- P is scale of yearly extraction, in tons.

In cases in which it is necessary to determine the ore reserves necessary for an enterprise, the above formula changes to:

$$Qq \doteq P \cdot t,$$

i.e., the ore reserves in the higher categories should, in terms of their absolute figures, equal the minimum yearly extraction multiplied by the normal period of existence of the mine enterprise (the normal amortization period of existence of an ore-mining enterprise is assumed to last 10-15 years).

As can be seen from the above, the degree of adequacy of ore reserves is determined by balance-sheet reserves multiplied by the index of extraction of mineral from deposit (Qq), i.e., adequacy of reserves is determined by the industrial reserves.

Example. When balance-sheet reserves amount to 4,000,000 tons, ore mining losses amount to 10 percent, and yearly extraction amounts to 360,000 tons, then the degree of adequacy of reserves will amount to:

$$t = \frac{4,000 \cdot 0.9}{360} = 10 \text{ years.}$$

It should be kept in mind that the division of ores into balance-sheet and extra-balance-sheet reserves is a nominal and extremely relative one.

Under the conditions of a rapidly developing technology, ores unsuitable for use at a given time may in the immediately following period be classifiable as balance-sheet ores and by the same token become an industrial raw material.

Before the introduction of the flotation process in the copper industry, when copper could be obtained only through shaft-furnace smelting, the ores containing less than two percent copper used to be an unprofitable raw material classified in the group of extra-balance-sheet ores.

Later, the requirements for copper ores had changed radically upon the transition to flotation and reverberatory smelting. The practice of the copper industry in the United States shows that during the 1891-1900 period the average content of copper in the beneficiated ores (beneficiated without flotation) amounted to 3.8 percent during the 1911-1920 period, upon the introduction of the flotation process, it dropped to 1.64 percent; and lastly in 1937, when an overwhelming part of copper ores was undergoing flotation), it

dropped to as little as 1.29 percent.

In the copper industry of the USSR during the Reconstruction Period, in the presence of the copper-blast-furnace smeling of copper ores alone, such ores as the Levikhinskiy impregnated ores in the Urals and the porphyric ores of Kounrad used to be regarded as extra-balance-sheet ores, because of their low content of the metal.

As of 1928/1929, i.e., upon the activation of the first concentrator plant of the Soviet copper industry, the Levikhinskiy and Kounrad deposits had become sources of industrial reserves.

When examining the question of the possibility of using a ore and the degree of its profitability, the following factors are of decisive importance:

(1) Content of metal in ore;

(2) Possible percentage of recovery of metal during the beneficiation of ore;

(3) Extraction cost per ton of ore;

(4) Expenditures on transporting the raw material;

(5) Cost of processing ore at the concentrator plant and at the metallurgical plant.

The interrelationship of these factors can be expressed by the following formula:

$$S = \frac{100 \cdot (p+n+t)}{f \cdot e}$$

where S is production cost per ton of metal;

f is content of metal in ore brought to surface;

E is total coefficient of recovery of metal at the concentrator plant and at the metallurgical plant;

p is extraction cost per ton of ore;

n is cost of concentration and metallurgical retreatment per ton of ore;

t is transporting cost per ton of ore.

Example. The content of metal in an ore amounts to 2.5 percent, the total recovery of the metal from the ore amounts to 80 percent, the extraction cost per ton of ore amounts to 30 rubles, the processing cost per ton of ore amounts to 25 rubles, and the transporting cost per ton of ore amounts to five rubles. Then the production cost per ton of finished metal will amount to:

$$S = \frac{100 \cdot (30+25+5)}{2.5 \cdot 0.8} = 3{,}000 \text{ rubles}$$

The thus calculated production cost per ton of metal will show the extent to which the exploitation of a given deposit is economically expedient and profitable. When, however, it is a question of selecting one from among several deposits, then a calculation of this kind should reveal which of the mining objects is most suitable for immediate exploitation.

The above-cited formula does not, of course, provide a complete and ultimate solution of the problem for all cases, because economic valuation is based on, in addition to the above-enumerated factors, also the consideration of other factors such as civilization of the region, presence of labor force, content of other valuable components in the ore, etc. The presence of other metals and the feasibility of their side-recovery during the comprehensive processing of the raw material increase greatly the economic value of the ore of a given deposit.

The recovery of gold and silver during the smelting of lead, the side recovery of molybdenum during copper production and cobalt during nickel production -- all this not only cuts the production cost of the principal metal but also makes it possible to obtain precious and rare metals in a less expensive manner than when extracting them from special (gold, molybdenum, cobalt) ores....

CHAPTER V

Production Planning under the Conditions of a Comprehensive Utilization of Raw Materials

1. The Multi-Component Character of the Ores of Nonferrous Metals

The comprehensive utilization of raw materials in nonferrous metallurgy is the paramount task of this branch of industry.

The directives of the Party and State about the economical consumption of raw materials are of a particularly actual importance to nonferrous metallurgy, which is characterized by the low content of metals in ores.

According to the data of contemporary practice, the approximate consumption of ore per ton of ingot metal is calculated in the following quantities (in tons):

Aluminum	6-8
Zinc	20-30
Lead	30-50
Copper	50-70 and more
Nickel	100-150
Rare metals	300-500 and more

At such high consumption norms, Socialist economics requires that the ores of nonferrous metals should in all cases be utilized with maximum completeness and efficiency.

The complete utilization of ore raw materials signifies the maximally possible recovery of not only the principal nonferrous metals but also all rare and precious components included in the composition of the processed ores.

In the system of planned economy reigning in the USSR a successful, rapid and practically correct solution to the problems of the comprehensive processing of raw materials can be found only upon the conditions that these problems are included as an organic component part in the plan of every branch and every enterprise of nonferrous metallurgy.

The ores of nonferrous metals are, as noted previously, in the tremendous majority of cases, complex, multi-component ores containing in addition to principal metals a number of useful and extremely valuable components (Table 43).

It follows from the above data that secondary components account for a large share /of the value/ of copper

Table 43

Share of Components in the Value of Ores (in percent)

	[Ore of] One of the Altay Polymetal Deposits	[Ore of] One of the Ural Copper Deposits
Copper	5	29
Zinc	19	18
Lead	15	--
Gold	51	39
Silver	6	4
Cadmium	1.5	--
Sulfur	2.5	8.5
Iron	--	1.5
Total	100	100

and lead-zinc ores, and that in a number of cases the principal nonferrous metals rank second or even third in their share in this value. The data of scientific-research work show also that the ores of nonferrous metals contain in addition such rare and dispersed elements as antimony, bismuth, selenium, tellurium, thallium, indium, gallium, germanium, etc. If the value of the rare and dispersed elements is included in the value of ore, then the share of the principal metals will be expressed in still lower percentages. Practice shows that rare and dispersed elements are contained in ores in negligible amounts expressed in tenths of a percent, but during the processing of ores these elements tend to accumulate in definite products of the production process -- very often in the tailings and wastes whence these elements can be successfully recovered.

Cadmium is contained in hundredths of a percent in polymetal ores, but already in zinc concentrates its content rises to 0.15 percent and higher. The content of cobalt in copper and nickel ores is expressed in insignificant parts of a percent, but in the tailings of copper flotation it rises to 0.02-0.025 percent, and in converter slags at nickel smelting it reaches 0.2-0.25 [0.25?] percent. The content of gallium in bauxites amounts to 0.001 percent, but in filter sediments it reaches 0.007-0.02 percent. The waste cakes of zinc-electrolysis plants contain indium and gallium. Assays of the copper-blast-furnace dust at a copper-smelting plant revealed that it contained: selenium -- 0.3-0.4 percent; germanium -- 100-400 grams/ton; and thallium -- 50-200 grams/ton. The collectors for selenium and tellurium are

the slimes of the copper electrolysis plants, and for bismuth -- the slimes of the electrolytic refining of lead.

2. Multi-Component Ore Processing Practice in Nonferrous Metallurgy

Throughout its history the nonferrous metallurgy of the USSR has been extensively engaged in furthering the comprehensive utilization of ores. Substantial funds, assigned for introducing the comprehensive methods of ore processing, have been invested in the construction of new concentrator plants and metallurgical plants and in the modernization of the existing such plants. The already existing enterprises maintain production shops and special facilities and installations making it possible to obtain not only the principal nonferrous metals but also a number of other, side-recovered valuable components. The comprehensive utilization of ores has in practice served as the basis for a broad expansion of the industrial cooperation of enterprises within the /framework of the/ system of branches of nonferrous metallurgy and, in turn, of cooperation between nonferrous metallurgy and other branches of industry (chemical industry, ferrous metallurgy).

In the Enterprises of the Copper Industry the following products are side-recovered in addition to the production of copper:

(a) Zinc -- in zinc concentrates obtained upon the selective flotation of copper-zinc ores;

(b) Sulfur -- in pyritic concentrates in the Ural concentrator plants, and in the form of the elementary sulfur produced by copper-sulfur plants;

(c) Gold and silver, recoverable into blister copper from copper ores and gold-bearing fluxes, with subsequent extraction of doré metal during the refining of blister copper;

(d) Selenium and tellurium, accumulating in the slime shops of copper-electrolysis plants;

(e) Nickel sulfate, obtainable in the sulfate shops of refining plants;

(f) Molybdenum concentrates obtainable from the flotation of copper-molybdenum ores;

(g) Arsenic gases collectible during copper-blast-furnace smelting in copper smelting plants.

In the Lead-Zinc Industry the following are obtained in addition to lead and zinc:

(a) Copper concentrates -- in a number of concentrator plants;

(b) Copper matte -- during lead-blast-furnace smelting in lead plants;

(c) Copper sulfate -- from the wastes of production upon the retreatment of copper-cadmium cakes in zinc electrolysis plants;

(d) Cadmium -- from the copper-cadmium cakes of zinc electrolysis plants;

(e) Gold and silver -- in the form of doré metals during the refining of lead in lead plants'

(f) Barite -- in the form of concentrates obtainable during the flotation of zinc ores;

(g) Bismuth -- during the refining of lead;

(h) Antimony -- from the retreatment of the alkali melts obtained when refining lead according to the Harris method;

(i) Sulfur -- in the form of pyrite concentrates and the sulfuric acid obtainable from the waste sulfur gases in zinc plants.

Side by side with the positive results and achievements in the field of the comprehensive utilization of raw materials in enterprises of nonferrous metallurgy, there also exist major shortcomings.

Modern practice shows that in the day-by-day production operations the attention and efforts of every enterprise are nearly completely centered on the maximal obtainment of "its own" principal metal. All the other, side-recovered components are regarded as secondary or even as harmful impurities which should be gotten rid of by various methods, without considering their in-production losses. Heretofore the practice of the processing of multi-component ores has been characterized by the following facts:

1. In the Ural copper-smelting plants the copper blast furnaces are often charged with copper-zinc ore containing from five to 10 percent zinc, which in such cases becomes completely forfeited in the dumped slags and waste gases. Because of the absence of a concerted dust collection a considerable amount of valuable components (zinc, lead, cadmium, selenium, tellurium, etc.) is expelled into the atmosphere together with the copper-blast-furnace dust.

2. In certain copper smelting and zinc plants all of the sulfur contained in the processed ores is lost in the furnace waste gases. According to production calculations, the irreversible losses of sulfur in copper smelting plants in 1938 were evaluated at 52 million gold rubles.*

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*L. M. Gazaryan. "Problem of Utilizing the Sulfur-Bearing Gases of the Nonferrous Industry During the Third Five-Year Plan," Tsvetnyye Metally /Nonferrous Metals/, No. 4-5, 1939.

3. Although the production of cadmium is already being conducted on an industrial scale, the content of this metal in ores and the degree of its recovery during flotation have as yet remained little investigated. The calculation of the recovery and losses of cadmium in production commences only from the moment when it is metallurgically processed. Statistics attest that cadmium is lost in considerable amounts during the processing process. As for the other rare and dispersed elements, the degree of their investigation and industrial mastering is even lower.

4. The [zinc] distilling plants fail to utilize the extensive accumulated dump heaps of residual slag containing as much as 10 percent zinc, 1.3-3 percent lead, 1.5-2 percent copper, and 0.1 percent cadmium.

5. The long-accumulated tailings of the Leninogorsk concentrator plants are estimated at 1.8 to 2 million tons, and their average content of lead amounts to 0.5-1 percent, and zinc -- 1.3-3 percent. Moreover, these tailings contain copper and precious and rare metals.*

6. The lead plants, in the many years of their operation, have accumulated slag heaps estimated at several hundred thousand tons and containing 1.5-3.9 percent lead and 6-12 percent zinc.**

There exists a great number of facts confirming the postulate that the multi-component ores are still being unsatisfactorily utilized in nonferrous metallurgy. One of the reasons for such a situation is the bureaucratic "monometal" attitude displayed toward raw materials and production wastes by the enterprises and main branch-of-industry boards of nonferrous metallurgy.

A sizable role here is also played by the existing methods of production planning, which fail to assure a proper approach to the problems of the comprehensive utilization of raw materials and by the same token fail to mobilize the attention of enterprises in this pressing task.

3. Shortcomings of the Existing Methods of Production Planning

According to the established procedure, the enterprises and main boards of nonferrous metallurgy draft detailed plans and justificatory technical and economic calculations

*S. A. Pervushin. "Dump Heaps of Ore, Tailings and Slags -- the Country's Highly Valuable Raw Material Resources." "Tsvetnyye Metally," No. 8, 1939.

**Ibid.

for the output of the principal metals for every branch, and it is only in isolated instances that the final indexes stipulate targets for the recovery of secondary components.

The technical indexes of recovery and the scale and types of losses and the general balance sheet of metals in production are drafted only according to the components being utilized at the present and within the limits of the roster /of components/ officially confirmed for a given enterprise or branch-of-industry main board. It is this that serves as the basis for all other calculations and the indexes of the "tekhpromfin plan" /technical, industrial and financial plan/, -- variety of output, production cost, accumulation /profit/, etc.

The question of the complete chemical composition of ores and concentrate and the degree of utilization of the complex whole of the value of ores has not as yet been properly placed before the enterprises of nonferrous metallurgy.

The components which are not being recovered at present from the raw material disappear from the economics of the enterprise and the branch of industry, even though they constitute a real national-economic value.

The presence of dump heaps of ores of past and present extraction, the accumulation in immobile reserves of the tailings of concentrator plants, the residual-slag heaps in the zinc-distilling plants and the slag dumps in the copper and lead plants -- all this is also largely to be explained by the narrowly administrative one-sided approach to all these resources, particularly to the production wastes.

The importance and practical value of production wastes are determined according to the percentile content of one or two principal metals -- copper in the copper enterprises, and lead in the lead enterprises, and so forth.

Upon another approach, upon determining the full chemical composition, the old dumps and current production wastes could represent an abundant source of raw materials, so to speak, ready-made "ores on the surface."

Measures for introducing the comprehensive processing of ore raw materials and expanding the number of the utilizable components are not being introduced into the system of indexes of the technical-industrial-financial plan of enterprises, and consequently the tremendous benefits which could thereby accrue are not taken into account in the calculations.

The effectiveness of the comprehensive methods of production manifests itself in two trends:

(1) Increase in the indexes of recovery of principal metals as a result of the retreatment of production wastes;

(2) Increase in the number of side-recoverable valuable components that affect substantially the entire

economics of the enterprise (volume of output, indexes of labor productivity, production cost, profitability of production).

Calculations conducted for one of the zinc plants showed that while the recovery of zinc through a one-cycle processing of the raw material amounts to 75 percent, the subsequent retreatment of zinc production wastes raises the zinc recovery index to 86.7 percent, i. e., under such conditions, the recovery of the principal metal increases by 11.7 percent.

The influence of the degree of utilization of raw materials on production cost and profit is illustrated by the following data of practice (Table 44).

Table 44

Relationship Between Production Cost and Profit and the Comprehensiveness of Utilization of the Raw Material(1)

	Production cost and profit in percent of Version I	
Version I -- Single-cycle technological scheme (retreatment of concentrates)	100	-
Version II - Double-cycle technological scheme (complementary retreatment of cadmium cakes)	80	20
Version III -- Triple-cycle technological scheme (retreatment of copper cakes)	72	28
Version IV -- Quadruple-cycle technological scheme (retreatment of waste cakes)	52	48

(1) N. M. Boldyrev, "Intra-Plant Planning, Production Cost and Profitability Upon the Comprehensive Processing of Multi-Component Raw Material" Tsvetnyye Metally, No. 8, 1939.

Secondary components are, as a rule, of high value and therefore their recovery, even if only in a small volume, may serve as an enormous potential for cutting the cost of principal production and increasing the profitability of production in the enterprises of nonferrous metallurgy.

The great value of the secondary elements is illustrated by the following comparison of the sales prices of nonferrous and rare metals on the foreign markets. Assuming the price

of copper at unity, the prewar sales prices of the other elements on the foreign markets stood in the following relation thereto:

Copper	1.0	Selenium	17.7
Lead	0.46	Molybdenum	27.5
Zinc	0.45	Thallium	68.9
Cadmium	5.42	Indium	8,340.0
Bismuth	10.8	Gallium	14,600.0
Tellurium	15.2	Germanium	32,000.0
Cobalt	17.5		

These comparison data illustrate the enormousness of the value lost when our polymetal ores are incompletely utilized. The interest of the national economy and defense requires that production planning in nonferrous metallurgy should be reshaped from the standpoint of a comprehensive, maximally complete utilization of ore raw materials.

4. The Needed Reorganization of Production Planning for a Comprehensive Processing of Raw Materials

The planning of complex production in nonferrous metallurgy should be based on the chemical composition of the ore raw materials, semifinished products and production wastes. Ore extraction in nonferrous metallurgy involves the outlay of substantial human and material resources, and therefore the extracted ore should be utilized with maximum efficiency.

The conduct of scientific research work, designing of new shops and enterprises and drafting of long-range and current output plans should be based on a radical overcoming of the one-sided narrowly administrative approach to the processed ores and concentrates.

In every case it is necessary to raise the question not of the degree to which one or two principal metals of a branch are extracted but of the content of the raw material and the completeness of the utilization of the complex whole of elements present in the raw material.

For this purpose it is necessary that every branch and every enterprise of nonferrous metallurgy should, when drafting output plans, proceed from the basis of the full composition of valuable components in the minerals and should have a clear idea about the degree of utilization of the raw material during its beneficiation and metallurgical processing.

Every output plan should cite a progressive balance sheet of materials, taking into account not only the industrial components being recovered but also the components

which for various reasons are not being utilized at present.

This approach should show:

(1) What is contained in the ore raw material;

(2) What metals and to what extent are being recovered during the processing of given raw material in a given enterprise;

(3) Which of the components are not being utilized and are being totally lost in the given enterprise.

When determining the technical and economic targets with regard to the recovery of the utilized metals it is necessary, during the drafting of the plan, to clarify completely the reasons why the other components are not being utilized.

Actual data show that the reasons for the losses of ore components are:

(a) Insufficient knowledge about the content of /secondary/ components in the raw materials;

(b) Lack of an elaborate technological scheme for recovering these components from the raw material;

(c) Insufficiency of basic equipment for recovering the secondary components;

(d) Absence of appropriate facilities or equipment for this purpose;

(e) Unclear demand or absence of demand at a given time for the various individual components.

The clarification of all these reasons will make it possible to outline the technical and organizational measures necessary for every planning period: conduct of geologic-prospecting and scientific-research work on the study of the content and properties of various individual components, elaboration of an efficient technological scheme for the components whose industrial production has still not been mastered, cooperation of enterprises in the processing of semifinished products and production wastes, capital expenditures on the expansion of the existing shops, construction of new special installations, conduct of purely organizational measures, etc.

All the measures drafted for utilizing the secondary components should be incorporated as an inseparable organic part into the output plans of the enterprises and branches of industry.

The recovery of secondary components should find its full reflection in all headings of the technical-industrial-financial plan of the enterprise -- in the volume of planned output, production cost, profit, etc.

Of great practical importance in this field could be the problem of assessing the comprehensiveness of utilization of raw materials both for the individual enterprises and for

entire branches of nonferrous metallurgy.

During the drafting of plans and assessing of the actual performance of enterprises and branches of nonferrous metallurgy it is necessary to take into account not only the percentage of recovery and loss of the principal metal but also the over-all index of comprehensiveness of recovery indicating the extent and the efficiency with which the ore raw material is being utilized with regard to all of the valuable components it contains.

The methods of calculating this comprehensiveness are illustrated by the following nominal example (Table 45).

Table 45

Calculating the Over-All Index of Comprehensiveness

Indexes	Metals					Over-All Index of Comprehensiveness
	A	B	C	D	E	
Calculated in kind						
Raw or used	10000T	20000T	5000T	2000Kr	30000Kr	
Recovery into marketable output	8500	18000	2500	1400	Not Utilized	
Calculated by value						
Nominal prices, in rubles	200	400	800	3000	100	
Raw ore used	2000	8000	4000	6000	3000	23000
Recovery into marketable output, in thousands of rubles	1700	7200	2000	4200	Not Utilized	15100
Recovery index, in percent	85	90	50	70	-	66

As can be seen from the Table, the over-all index of comprehensiveness is calculated in the following manner:

(a) The Balance sheet of both the metals contained in the raw ore used and those recovered into marketable output is compiled in natural indexes;

(b) The value of both the processed metals and the recovered metals is calculated in the same prices;

(c) The figures on the value of the processed and the recovered metals, respectively, are mutually compared so as to deduce the over-all index of comprehensiveness of utilization of the raw materials (66 percent).

This index of comprehensiveness can be deduced for a single enterprise if the entire processing /ore beneficiation and metallurgical reduction/ of the raw material is done within that enterprise.

On the other hand, in cases in which the semifinished products or production wastes of a given enterprise are transferred for further processing to other enterprises, the comprehensiveness index can be calculated according to the total recovery of metals in several enterprises. In such cases the comprehensiveness index will indicate the extent of the comprehensiveness with which an ore raw material is being utilized by an entire branch of industry as a whole. The degree of the comprehensiveness of utilization of raw materials is a criterion for evaluating technological schemes, an index of the level of technology, economy and culture of production.

5. Examination of the Comprehensiveness of Utilization of Raw Materials in Individual Enterprises of Nonferrous Metallurgy

The utilization of ore at one of the Ural concentrator plants is expressed by the following indexes (Table 46):

Table 46

Utilization of Ore Components at An Ural Concentrator Plant

Index	Copper	Zinc	Gold	Silver	Sulfur	Total
Delivered to the plant for processing						
Value of components in ore, in thousands of rubles	11047	4292	2816	447	4407	23009

/Table continued on next page/

/Table 46 continued from page 16/

Index	Copper	Zinc	Gold	Silver	Sulfur	Total
2. Obtained at the plant Value (in thousands of rubles) of components recovered into:						
Copper concentrates	9376	1162	1216	268	405	
Zinc concentrates	174	1293	104	-	177	
Pyritic concentrates	161	201	-	-	594	
Total	9711	2656	1320	268	1176	15131
3. Utilization of components, in percent	87.9	61.9	47.0	60.0	26.7	66

The uncontrolled passage of some metals into the concentrates of other metals (copper into zinc concentrates and zinc into copper and pyrite concentrates) can be assumed only as a nominal recovery, because it is a result of incomplete selection at the plant and in the majority of cases it leads to a sizable or even complete loss of these metals. At the plant examined here the passage of zinc into copper and pyrite concentrates and the passage of copper into zinc and pyrite concentrates is essentially tantamount to the loss of these metals, not only for the enterprise but also for the branch as a whole. Considering that at the given plant sulfur /from the waste gases/ is not trapped, all of the sulfur contained in the copper concentrates has also to be added to these losses.

If we take these losses into account in our calculations, then the value of the usefully recovered components has to decline by the following extent:

Zinc in:	Value in thousands of rubles
Copper concentrates	1,162
Pyrite concentrates	201

/Continued on next page/

/Continued from page 17/

Copper in:	Value in thousands of rubles
Zinc concentrates	174
Pyrite concentrates	161
Sulfur in copper concentrates	405
Total loss	2,103

Upon this correction, the total value of the usefully recovered components will equal:

15,131--2,103 = 13,028 thousands of rubles

Hence the over-all index of comprehensiveness of utilization will amount to:

$$\frac{13,028.100}{23\ 009} = 57 \text{ percent}$$

This Ural plant has fulfilled 100 percent its annual plan target with regard to the amount of processed ore, and the actual recovery of copper into copper concentrates at this plant has amounted to 85 percent against the plan-stipulated 87 percent.

If this plant is regarded as a copper enterprise alone, then the results it obtained cannot be open to any severe criticism, because the actually achieved indexes are very close to the plan-set ones. But a totally different picture and totally different conclusions are obtained when the utilization of the ore as a whole at this plant is analyzed. The comprehensiveness index shows that the useful recovery amounted to only 57 percent of the total value of the components contained in the processed ore.

Indisputably, not all of the other 43 percent is to be regarded as technically uneliminable losses, but it is patently obvious that the 57-percent comprehensiveness index for this plant attests to an unsatisfactory utilization of the raw material.

Taking not the plant as a shole but only its department for the selective (copper-zinc) flotation, and comparing the actual indexes at that plant with the practice of foreign plants, the following picture will be obtained (Table 47).

Table 47

Comparison of the Comprehensiveness Index of the Ural Plant With That of the Foreign Plants

Index	Copper	Zinc	Sulfur	Comprehensive Index
Tennessee Copper Co. (United States)				
Content in ore, in percent	1.68	1.04	19.70	-
Recovery, in percent	91.5	42.4	67.4	81
Britannia (Canada)				
Content in ore, in percent	0.60	1.35	5.0	-
Recovery, in percent	31.0	65.0	46.25	71
Ural Plant				
Content in ore, in percent	2.2	4.9	24.10	-
Recovery, in percent	86.0	57.9	31.0	67.6

Although the above-mentioned foreign plants process ore with a lower content of copper, zinc and sulfur, the comprehensiveness index of the Ural plant is, when calculated by the same method, lower than in the foreign plants.

A Copper Smelting Enterprise

Calculations of the utilization of ore raw material at one of the copper enterprises (concentrator plant and copper-smelting shop) yield the following results (Table 48).

Table 48

Utilization of Ore Components at a Copper Smelting Enterprise

Index	Copper	Zinc	Sulfur	Gold	Silver	Comprehensive Index
1. Amount of metals processed						
Total value of metals in ore, in thousands of rubles (in nominal prices)	35,684	9,476	11,525	24,390	1,719	82,794
2. Obtained output						

/Table continued on next page/

/Table continued from page 19/

Index	Copper	Zinc	Sulfur	Gold	Silver	Comprehensive Index
Total value of the recovered metals, in thousands of rubles (in same nominal prices)	29,505	1,494	771	22,266	1,624	55,660
3. Degree of utilization, in percent	83.0	16.0	7.0	91.0	94.0	67.0

The following metals were considered in this calculation:

(a) Metals in the ore processed at the concentrator plant;

(b) Metals sent together with ore for copper-blast-furnace smelting;

(c) Metals in the imported concentrates processed in the reverberatory furnace of that plant.

The recovered metals were calculated according to the gross volume of marketable output of the enterprise (blister copper, zinc and pyrite concentrates).

Of the total amount of the recovered copper 83 percent passed into blister copper and the remaining 15 percent -- into zinc and pyrite concentrates and into returns.

The zinc recovered into marketable output, in the amount of 16 percent (1,494,000 rubles) was distributed as follows: 14 percent (1,293,000 rubles) had passed into zinc concentrates and two percent (201,000 rubles) -- into pyrite concentrates. The processed sulfur had a total value of 11,525,000 rubles, but only its part recovered at the concentrator plant became included in the marketable output, namely: the sulfur in the pyrite concentrates, valued at 177,000 rubles of 5.5 percent, and the sulfur in zinc concentrates, valued at 177,000 rubles or 1.5 percent of the entire amount of the sulfur contained in the processed raw material.

As for gold and silver, their recovery indexes at the enterprise are fairly high (91-94 percent). This is largely attributable to the fact that these metals were preponderantly obtained in copper-blast furnaces, where their recovery is high.

If the performance of this enterprise is regarded from the viewpoint of the copper industry, then the index of recovery of copper into blister copper (81.5 percent) (taking into account concentration and metallurgical reduction) and the above-cited indexes of recovery of the precious metals provide a foundation for acknowledging the performance of the enterprise as satisfactory.

But if other criteria are used in the appraisal and if we ask the question of how is the raw material utilized by the given enterprise, then opposite conclusions have to be made; the extremely low zinc recovery index and the negligible percentage of utilization of sulfur indicate that the enterprise is still sustaining enormous national-economic losses verging on the squandering of valuable components -- zinc and sulfur.

A Zinc Combine

The utilization of the individual components and the complex whole of the valuable components of raw materials at a zinc combine is illustrated by the following indexes (Table 49):

Table 49

Utilization of Ore Components at a Zinc Combine

Ore Component	Value of Component (in thousands of rubles)		Utilization of Component, in percent
	Value of the Component in the Ores and in Imported Concentrates	Value of the Component Recovered into Marketable Output	
Zinc	7045	5240	74
Lead	2155	1637	76
Copper........	1609	710	44
Gold	6120	3498	57
Silver........	1721	920	54
Cadmium.......	340	52	15
Barite........	9544	3880	41
Sulfur........	1624	Not Utilized	-
Grand Total	30158	15937	53

The obtained metals are calculated according to the

total marketable output, namely: spelter zinc, lead and barite concentrates, zinc sulfate, blue zinc powder, Cottrell filter dust, and gold slime.

It can be seen from the above calculation that the highest recovery indexes at this interprise pertain to zinc -- 74 percent (taking into account concentration and metallurgical reduction) and to the recovery of lead into lead concentrates and Cottrell dust -- 76 percent.

The state of utilization of every individual component stands on a very low level.

This enterprise loses all of the sulfur component.

The utilization of the ore raw material processed by this zinc combine is not completed there, because its residual slag heaps, containing a number of valuable components, are sent for retreatment to another zinc plant.

The additional recovery of components from the residual slags increases the indexes of utilization of the raw material of the zinc combine to the levels shown in Table 50.

Table 50

Recovery (in percent) of Components on Taking Account of Residual Slag

Metal	Recovery at Zinc Combine (Without Residual Slag)	Total Recovery (Including the Recovery from Retreated Slag)
Zinc	74	74
Lead	76	88
Copper	44	74
Gold	57	78
Silver	54	87
Barite	41	41
Cadmium	15	22
Sulfur	Not utilized	
Average Total	53%	61%

The increase in the degree of utilization of the raw material in the given case was achieved as a result of: passing lead from residual slag into lead metal, which has increased by 12 percent the degree of utilization of that metal; passing copper into copper matte -- an increase of 30 percent; passing gold and silver into dore metal -- an increase of 21-33 percent; and passing cadmium from residual

slag into Cottrell filter dust -- an increase of seven percent.

From the example of this zinc combine we can see that cooperation between enterprises with regard to the retreatment of wastes can improve substantially the indexes of the recovery of ore raw material and by the same token increase the over-all indexes of its utilization.

If an ore raw material passes, in the course of its processing, successively through a number of enterprises, then the comprehensiveness of its utilization can be calculated not only according to a single separately taken enterprise but also within the framework of the entire concerned branch of nonferrous metallurgy on taking into account the results obtained from the cooperation of enterprises.

The foregoing examples demonstrate graphically that the examination of the completeness of utilization of raw materials is an actual and important practical problem for nonferrous metallurgy.

Proceeding from the achieved level of technology it is possible to determine in advance for any given period the maximum possible and optimal indexes of recovery for every component. This would make it possible to divide the total losses of metals into two parts: (a) losses made inevitable by the present state of production technology; and (b) redundant losses which are a consequence of unsatisfactory approach by the enterprise.

At present, when the Fourth Five-Year Plan postulates the goal of an omnilateral increase in the technical level of production and the introduction of the achievements of pace-setting echnology in all branches of industry, nonferrous metallurgy should assure all the conditions for a maximally efficient utilization of the processed ore raw materials.

The Law of the Five-Year 1946-1950 Plan stipulates the task of organizing the comprehensive utilization of all useful minerals contained in the ores of nonferrous metals, including the sulfur-bearing raw materials, through the application of improved processing methods and the combining of nonferrous metallurgy with the chemical industry.

CHAPTER VIII

Planning Industrial Output in Value Indexes

Output is calculated in natural measuring units (tons, cubic meters, kilograms, units, etc.) and in value indexes (according to production cost, sales prices for the plan-covered period, fixed prices).

When production is planned in terms of value, the following types of production are differentiated:

(a) Gross turnover;
(b) Gross output;
(c) Marketable output.

Gross turnover encompasses the value of all the finished products, semifinished products, and raw materials, produced in the basic, subsidiary and auxiliary shops.

Formula for gross turnover:

$$\text{BO} = \text{A} + \text{Б} + \text{Y}$$

where BO is gross turnover;
A is value of finished-product output;
Б is value of all semifinished products and raw materials produced;
Y is value of the industrial services of the shops (power, steam, etc.).

Thus, gross turnover represents the aggregate value of the output of the principal, subsidiary and auxiliary shops, not excluding intra-plant turnover.

In a nonferrous-metallurgy combine operating its own ore mines, concentrator plant, metallurgical plant, and power station, gross turnover will consist of the value of the following items:

(a) Extracted ore;
(b) Produced concentrates;
(c) Smelted metals;
(d) Generated electrical energy.

Gross output is construed as the value of the output (of products, semifinished products, and services) of all basic, subsidiary and auxiliary shops upon deducting the value of the output consumed by the enterprise itself.

Gross output includes the following:

(a) Finished and semifinished products designed for release to the outside;

(b) Increment or decrement in the inventory of the

semifinished products made by the enterprise;

(c) Provision of industrial [power, steam, etc.] services to the outside.

In the industries with a lengthy production process (machine building, forestry, peat industry), changes in uncompleted production are also taken into account in the composition of gross output.

In the enterprises of nonferrous metallurgy, changes in uncompleted production are not included in gross output.

The difference between semifinished products and uncompleted production consists in that the semifinished products (ore, concentrates, matte, anodes, alumina, crude lead, etc.) can be transmitted to other plants, whereas uncompleted production represents assets in the state of processing (extracted ore <u>in</u> bins, pulp <u>in</u> flotation tanks, charges in metallurgical furnaces, blister metal <u>in</u> refining equipment, etc.).

The formula of gross output is as follows:

$$\text{BП} = A + (\text{Б} - b) + y$$

where BП is gross output;
- A is value of the output destined for release to the outside;
- Б is value of the raw material at the enterprise and of all the produced semifinished products;
- b is value of the semifinished products and raw materials retreated within the enterprise;
- y is industrial services [steam, power, etc.] to the outside.

Gross output can be calculated by deducting from gross turnover the value of all the types of semifinished products utilized within the confines of the enterprise itself, i. e., by excluding intra-plant turnover.

Industrial services pertain to the output of the auxiliary shops (electrical energy, steam, gas, water, etc.) which is provided to the outside, to the enterprises's own capital construction, to capital repairs, and to the nonproduction needs of the enterprise (communal economy, cultural services, etc.).

The services provided to the outside by the intraplant transport are not included into gross output.

The purpose of calculating the "gross output" index is to:

(a) Determine the physical volume of output;

(b) Provide the general dynamics of production for a number of years;

(c) Establish a basis for calculating labor productivity.

In plans and reports, gross output is calculated in terms of the fixed 1926/1927 prices.

When new types of production, for which no fixed 1926/1927 prices exist, are included into plans, the determination of fixed prices for these new types is based on the actual or planned production cost under the conditions of mass production of these new types and upon applying the correction factory which is determined by the ratio of 1926/1927 fixed prices to the production costs of the output of related or analogous types of production.

As for the value of services of an industrial character, provided to the outside, it is calculated according to the established fixed prices: e. g., the electrical energy supplied to the outside is priced at 6.5 kopeykas per kwt, water -- 18.5 kopeykas per m^3, steam -- 10 rubles per mgkal /megacalorie?/, etc.

One advantage of the index of gross output is that its calculation involves the deduction of all internal turnover and thus, in contrast with the index of gross turnover, it eliminates the repetition of calculations. When contrasted with marketable output, gross output indicates the value of all the products of value created at the enterprise (in the form of finished and semifinished products).

However, the "gross output" index has also shortcomings of its own, shortcomings which should not be overlooked when using it.

Primarily, gross output does not always reflect the structural changes in the composition of the enterprise. Thus, e. g., when an ore mine and a metallurgical plant which had previously existed as independent enterprises become merged into a single combine, the gross output of that combine will not differ in any way from the gross output of the metallurgical plant but the combine's personnel will be numerically much larger than the plant's personnel, because of the incorporation of the mine. In such a case, even if the labor productivity of the workers of the mine and plant will increase, the gross output per worker of the combine will decline drastically.

Further, if the rate of ore consumption at a mining-metallurgical enterprise increases as a result of the depletion of the richer ores, then, even if the annual output of metal is maintained on the same level, it becomes necessary to expand mining operations and to alter to a definite extent the numbers of the labor force, -- and this will in no wise be reflected in gross output of the enterprise.

Moreover also, every ore-mining enterprise conducts not only stopping work but also mine-development operations -- operations that may fluctuate broadly in scale and in the

number of workers engaged on them during individual periods, -- and this also is not reflected in gross output.

Gross output does not reflect with sufficient accuracy the actual volume of output because of imperfections in the accounting of uncompleted production in the nonferrous-metallurgy enterprises in which the production cycle is lengthy, particularly in the copper electrolysis plants.

The technological process of copper electrolysis requires a 20-30 day sojourn of immersed anodes in the bath.

The existing [accounting] practice ignores the influence of the changes in the inventory of the immersed anodes on the composition of gross output and, as a result, when the number of the operating [cell] series changes, this may distort strongly the volume of output in terms of value indexes for individual periods. However, despite its shortcomings, gross-output accounting is necessary to assess the volume of production of a branch of industry as a whole.

Table 60

Approximate Calculation of Gross Output in Fixed 1926/1927 Prices

Type of Production	Amount	Fixed Price	Total in thousands of rubles
Copper ore (in reserve)............	60 000	10	600
Copper concentrates (in reserve)...	4 000	100	400
Pyrite concentrates................	60 000	20	1 200
Blister copper.....................	16 500	1 000	16 500
Services to the outside............	-	-	300
Total..................	-	-	19 000

As for marketable output, it consists of: (a) finished output, i. e., finished and semifinished products destined for release to the outside; and (b) industrial services to the outside and for the enterprise's own capital construction, capital repairs and non-production needs.

Formula for marketable output:

$$ТП = A + y$$

where A is output ready for release, and
y is industrial services to the outside.

Marketable output is constituted by the OTK-approved

/OTK stands for the plant's quality control division/ finished complete output satisfying the established standards, technical requirements and contractual requirements. Rejects and substandard products are definitely not included at all in the plan.

"The production of low-quality or incomplete industrial output and the production of output violating the mandatory standards constitute an anti-State offense tantamount to saborage."*

All the types of output of a copper-smelting combine consisting of an ore mine, a concentrator plant and a metallurgical plant, are cited in Table 61.

Table 61

Calculation of Various Types of Output
(in thousands of rubles)

Kind of Output	Processed	Consumed	To Form a Reserve and to release to the Outside	Released to the Outside
Ore.................	7 000	6 400	600	-
Copper concentrates.	10 000	9 600	400	-
Pyrite concentrates.	1 200	-	1 200	1 200
Blister copper......	16 500	-	16 500	16 500
Services to the outside...........	1 300	1 000	300	300
Total......	36 000	17 000	19 000	18 000
	Gross Turnover	Intra-Combine Turnover	Gross Output	Marketable Output

It can be seen from the above example that if intra-combine (intra-plant) turnover is deducted from gross turnover, then we obtain the value of the gross output, and if the value of the nonprocessed semifinished products (ore, concentrates) is deducted from the value of gross output then we obtain the value of the marketable output.

Gross and marketable output are calculated by the

*Decree of the Presidium of the Supreme Soviet USSR of 10 July 1940.

plant accounting methods. This signifies that the output of a trust or main branch-of-industry board represents the sum total of the output of all the organizationally independent enterprises within the framework of the trust or under the jurisdiction of the main board.

Consequently, the calculation of the gross or marketable output on the scale of the trust or main board does not involve the deduction of any internal (intra-trust or intra-branch) turnovers.

The plans of marketable output are compiled in terms of the current sales prices (including the turnover tax), approved by the established procedure.

The method of calculating gross and marketable output according to current sales prices differs radically from the method used to calculate output according to fixed prices. While the fixed prices are established per ton of ore, concentrates or metals (without indicating the quality grade), the current sales prices are approved for the metal contained in the raw material or semifinished products and they correspond stringently with the quality and grade of the processed products.

If an ore or concentrate contains, in addition to the principal metal, a number of other valuable components as well, this will in no way affect the output calculated according to current sales prices will totally and entirely hinge on the kind and number of the processed components.

It follows from Table 62 that there does not exist any hard-and-fast sales price per ton of ore or concentrate, because the price of every type of raw material or semifinished product is calculated according to the established price per ton-percent of metal or per gram of gold and silver, and according to the number of metals contained in the raw material or semifinished product as well.

Table 62

Approximate Calculation of Gross and Marketable Output According to Current Sales Prices

Type of Output	Amount in Tons	Content of Components	Total Number of Components	Price of Components	Total in thousands of rubles
Copper ore	60 000	Copper 3% Gold 4 grams/ton	1,800 tons, 240 kg,	8 rubles per ton-percent	

/Table 62 continued on next page/

[Table 62 continued from page 29]

Type of Output	Amount in Tons	Content of Component	Total Number of Components	Price of Components	Total in thousands of rubles
Copper ore	60 000	Silver 80 grams/ ton	4,800 kg	5 rubles per gram 30 kopeykas per gram	1 200 1 440
Copper concentrates	4 000	Copper 20% Gold 20 grams/ ton Silver 400 grams/ ton	800 tons 80 kg 1,600 kg	11 rubles per ton-percent 12 rubles per gram 80 kopeykas per gram	4 080 880 960 1 280
					3 120
Pyrite concentrates	60 000	Sulfur 50%	30,000 tons	70 kopeykas per ton-percent	2 100
Copper grades:					
M-1	10 000	-	-	3 000	30 000
M-2	4 500	-	-	2 800	12,600
M-3	2 000	-	-	2 500	5 000
					47 600
Total gross output.					56 900
In which: marketable output (pyrite concentrates and copper)					49 700

CHAPTER X

The Planning of Production Cost

A. Technical and Economic Analysis of Production Cost

I. Methods of Production Cost Analysis

Production cost constitutes the synthetic qualitative index reflecting directly and indirectly all the strong and weak aspects of the performance of an industrial enterprise.

The production cost of one and the same product during different periods and in different enterprises may vary sharply depending on the level of the culture and technology of production, organization of labor, efficiency of utilization of equipment and raw materials, and care and economy with which material and financial means are expended on production.

Production cost is the basis of economic accounting /accounting in financially self-supporting enterprises/, it is a decisive factor in the cause of the struggle for a profitable operation and for socialist accumulation in industry. The principal tasks in the struggle for profitability are:

"...Elimination of mismanagement, mobilization of the internal potential of industry, introduction and consolidation of economic accounting in all of our enterprises, systematic reduction of production cost, intensification of intra-industry accumulation in every branch of industry without exception."*

In addition to the indexes of the quantitative output of products and of the quality of production, production cost is the fundamental index for evaluating the production activity of an enterprise.

A properly elaborated estimation of production cost should serve as the guiding factor in an operative management of production processes. According to the time of its compilation, the calculation of production cost can be either estimate-based (planned) or report-based (actual).

Production cost can be of the following types according to the extent to which it encompasses the outlay

*J. Stalin. "Problems of Leninism," Partizdat, 11th Edition, page 347. Address delivered at a rally of economic executives.

items: (a) shop production cost; (b) plant production cost; and (c) total or commercial production cost, which includes not only production outlays but also all marketing expenditures. Production cost targets are stipulated either in the form of planned cost per product unit or in the form of the percentage of reduction compared with actual mean annual production cost in the preceding period.

The reduction of production cost in percent is cited only for the comparable marketable output, on the basis of its total actual value.

Comparable output pertains to the output of the same variety of products during the preceding period in the same enterprise.

Non-comparable output pertains to the output which was not produced throughout an entire preceding period at a given enterprise. The plan for noncomparable output is provided only in the form of the estimated production cost per product unit.

The planning of production cost in the enterprise consists in the calculation of the estimated cost of the activities and products of all basic and auxiliary shops, with breakdown into the principal stages of the technological process and into the individual items of production outlays. The developed plan of production cost should serve as the basis for economic accounting, serving to reveal the quality of performance of every department and shop and providing the possibility for a systematic supervision of the performance of every sector of the enterprise.

The construction of the estimate-based calculation of production cost is closely related to the plan of organizational and technical measures, which stipulates the concrete paths for improving the performance and indicates the basic factors for planned calculation and for assessing the reduction in production cost.

The compilation of the plan of production cost should be preceded by: determination of the results obtained during the preceding reporting period, detailed analysis of the factors determining the level of production cost, and drafting of measures intended to cut the production cost of the enterprise.

The determination of the preceding period's results should be commenced by examining the accounting reports and the financial statement, which reflects the ultimate results of the entire production-economic activity of the enterprise.

The loss and profit accounting shows the financial results of the direct production activities, the extent of prifitability or unprofitability of production, and the results of the operations of a non-production nature (over-

estimate, surplus or deficiency of material-commodity means, list of debtors and creditors, etc.).

When summing up the results of the activities of the enterprise, it is primarily necessary to determine the over-all result with regard to production cost for the enterprise as a whole, with regard to the entire volume of the released marketable output.

Considering that the planned targets for production cost for the enterprise as a whole are stipulated in the form of the mean weighted percentage of reduction in that cost compared with the preceding reporting period, the examination of the actual results requires also the determination of the mean percentage of decline or rise in production cost for the period under analysis, compared with the production cost for the preceding (reference) period.

In the event that the enterprise manufactures only a single product, the change in the production cost per output unit will also reflect the over-all enterprise-wide result of the fulfillment of the plan of production cost.

A more complex picture may be presented by the results of production cost at an enterprise manufacturing several different products, the more so if the variety of the products is extensive.

Below is cited an example of the output of three products, each with a different production cost (Table 79).

Table 79

Change in the Production Cost of Different Products (in rubles)

Kind of Product	Preceding Period	According to the Plan for the Period Under Analysis	Actual Production Cost in the Period Under Analysis	Change in Production Cost During the Period Under Analysis -- decline (-) or rise (+) in that cost Compared With:	
				The Base Period	The Plan
				Rubles	
Product No. 1	3000	2700	2800	-200	+100
Product No. 2	620	600	600	- 20	0
Product No. 3	1050	1000	1200	+150	+200

To deduce the over-all result of the change in the production cost for the enterprise as a whole, it is necessary to multiply the actual output for the examined (analyzed)

period by the above-cited indexes of production cost and then, according to the reported figures, to determine the sought-for weighted mean result.

Such a calculation is presented in the form shown in Table 80.

Table 80

Reduction in Production Cost for the Enterprise as a Whole

Kind of Product	Output During the Analyzed Period, in tons	Cost of Output for the Analyzed Period According to the Unit Production Cost					
		For the Preceding (Reference) Period		Planned for the Analyzed Period		Actual for the Analyzed Period	
		Production Cost in rubles	Sum Total in thousands of Rubles	Production Cost in Rubles	Sum Total in thousands of Rubles	Production Cost in Rubles	Sum Total in thousands of Rubles
Product No. 1	20 000	3 000	60 000	2 700	54 000	2 800	56 000
Product No. 2	5 000	620	3 100	600	3 000	600	3 000
Product No. 3	10 000	1 050	10 500	1 000	10 000	1 200	12 000
Total	-	-	73 500	-	67 000	-	71 000

It follows from the above Table that:

(a) The cost of output for the analyzed period when based on the production cost of the preceding (reference) period, i.e., if production cost is maintained on last year's level, amounts to 73,500 rubles;

(b) The cost of the same output should amount to 67,000 rubles, or 91.2 percent of the above figure, when based on the planned production cost and hence, during the fulfillment of the plan, production cost should decline by 8.8 percent (100--91.2) compared with the preceding period;

(c) Actually, though, the cost of output for the analyzed period amounted to a total of 71,000 rubles which is equivalent to 96.6 percent of the cost during the reference period (73,500 rubles), i. e., production cost had actually declined by 3.4 percent.

Thus, while the plan of reduction in production cost envisaged an 8.8-percent reduction, the actual reduction in

production cost at the enterprise had amounted to only 3.4 percent compared with the preceding (reference) period.

Noteworthy here is the extremely poor result obtained with regard to product No. 3, whose production cost (1,200 rubles) proved to be not only higher than planned (1,000 rubles) but also higher than in the preceding period (1,050 rubles).

The foregoing is now reduced to the determination of the index of the change in production cost during the analyzed period as compared with the preceding period or with the plan.

This calculation can be expressed by the following formula:

$$X = \frac{P \cdot S_1}{P \cdot S_0}$$

where: X is index of change in production cost;
P is output of the analyzed period, in natural units;
S_1 is unit production cost of the output of the analyzed period;
S_0 is unit production cost in the preceding, reference period.

When calculating the resulting mean indexes of production cost, it is necessary to take into account the influence which may be exerted on production cost by a change in the variety of the manufactured products or in the proportions of the share of the output of each product.

This may occur at an ore-mining enterprise, where the conditions of extraction and hence also the production cost of ore may vary broadly in the individual mines or mine sectors of the enterprise.

To clarify this, let us consider the following example (Table 81).

In the given example we see that the production cost of extraction [i.e., in this case, extraction cost] has declined in all three mines but, nevertheless, the mean cost per ton of ore in the analyzed period (35 rubles) proved to be six percent higher than in the preceding period (33 rubles). Such an increase in mean production cost stems from the fact that the share of each mine in the total output [ore extraction] of the enterprise has changed drastically.

While the extraction [output] at the mine with a low production cost (Mine No. 3) has decreased substantially, the extraction at the mines with high production cost (Mines No. 1 and 2) has climbed sharply, which was also the principal reason for the rise in the mean production cost per ton

of ore.

Table 81

Influence of the Share of Each Mine in an Enterprise on the Changes in Production Cost

Mine	Preceding (Reference) Period			Period Under Analysis		
	Extraction, in thousands of tons	Production cost, in rubles	Total amount, in thousands of rubles	Extraction, in thousands of tons	Production cost, in rubles	Total Amount, in thousands of rubles
No. 1	200	40	8 000	400	38	15 200
No. 2	50	35	1 750	150	34	5 100
No. 3	200	25.5	5 100	100	24	2 400

It is perfectly obvious that such a mean index does not provide a correct idea about the change in the production cost for the enterprise as a whole, in the given case, and that the actual results with regard to production cost could be determined only through an appropriate and correct calculation.

The magnitude of the mean index (35 rubles) was obtained as a result of two factors, the shift in the respective share of each mine and the simultaneous decline in the production cost of extraction in the individual mines.

First of all, let us determine the change that would occur in the mean production cost if only one factor -- change in the respective shares of each mine -- were active, i. e., if the production cost of extraction in each mine during the analyzed period had remained on the same level as in the preceding period.

For this purpose, we will perform the following auxiliary calculation (Table 82).

Table 82

Influence of Changes in the Respective Share of Each Mine on the Production Cost

Mine	Ore Extraction During the Analyzed Period	Production Cost Per Ton of Ore During the Preceding (Reference) period, in rubles	Total Amount in thousands of rubles
No. 1	400	40	16 000

/Table 82 continued on next page/

[Table 82 continued from page 36]

Mine	Ore Extraction During the Analyzed Period	Production Cost Per Ton of Ore During the Preceding (Reference) period, in rubles	Total Amount in thousands of rubles
No. 2	150	35	5 200
No. 3	100	25.5	2 550
Total	650	36.6	23 800

It follows from the above calculation that, as a result of the changes in the respective share of each mine, the mean production cost per ton of ore climbed seemingly to 36.6 rubles from 33 rubles, but actually, thanks to the decline in extraction costs in the individual mines, it amounted to 35 rubles. Consequently, at the ore-mining enterprise considered here, the following results have been obtained with regard to production cost. Because of the changes in the respective share of each mine, the mean production cost per ton of ore climbed to 36.3 from 33 rubles, i. e., by 11 percent. At the same time, as a result of the decline in extraction cost in the individual mines, the mean production cost per ton of ore declined by 36.--35 = 1.6 rubles, or by five percent in relation to the previous production cost (33 rubles). In the final analysis, mean production cost rose to 35 from 33 rubles, i. e. by six percent.

The determination of the enterprise-wide results of the changes in production cost can be followed by the determination of the production cost of every individual product. The analysis should be extended not only to the indexes obtained for the year as a whole but also to the dynamics of production cost within the limits of the examined year.

The changes in production cost in the individual months and quarters of the year should indicate the periods during which the deviations from the planned targets are particularly wide, and the reasons behind the decline or rise in production expenses.

A deterioration in the index of production cost for a given product should constitute the signal for the adoption of technical and organizational measures for reforming the work in the unfavorable sectors.

At the same time, the examination of the dynamics of production cost in the individual periods makes it also possible to uncover the best indexes and to determine the optimal

levels to which the production cost had already declined without vitiating the performance of the enterprise. It is particularly important to be familiar with the concrete level of the production cost at the end of the period under analysis, because essentially that level constitutes the datum for the decline in production cost during the succeeding period.

The analysis of the production cost of a finished product should, naturally, lead to the examination of production cost indexes for the individual shops and metallurgical departments.

At a mining-metallurgical combine of nonferrous metallurgy, the production cost of a finished product will consist of the operating expenditures on the extraction of raw material, its concentration, and its metallurgical processing. It is therefore extremely important to clarify the respective roles of the combine's ore mine, concentrator plant and metallurgical shops, in the change in the production cost of the released marketable output.

Further, it is necessary to examine the influence of every principal part of the production process of a shop on the production cost of the shop. Thus, at the concentrator plant, the cost of ore beneficiation consists of the combined total of the costs of the operations of crushing-grinding, flotation, and dehydration. Here, special attention should be paid to the operations of decisive importance to production cost. For example, it is known that, during the beneficiation of ore, crushing and fine grinding are the most expensive operations accounting for over 50 percent of the over-all cost of beneficiation.

At the metallurgical plant, production cost has to be examined according to the individual stages of the process (roasting or sintering, smelting, refining, etc.).

In many enterprises of nonferrous metallurgy the level of production cost is, moreover, greatly affected by the activities of the subsidiary-auxiliary shops.

The extraction of fuel and fluxing agents by the enterprise itself, the generation of electrical energy, compressed air and steam by the enterprise, freight haulage by the enterprise's own means of transport, the services provided by the repair and machine shops -- all these types of production affect radically both the quantity and the cost of marketable output.

The more intricate and diversified are the activities of an enterprise, the greater its opportunities for reducing the production cost of its principal output by reducing the production costs of /its secondary output in the form of/ extraction of raw material and fuel, generation of electrical

energy, repair work, and intra-plant transport.

It is sufficient to mention that in the copper and nickel industry a five-ruble reduction in production cost per ton of ore causes the cost per ton of finished metal to be 400-600 rubles lower; in the aluminum-magnesium industry, a two-kopeyka reduction in the cost per kwh yields a saving of 350-500 rubles in the power expenditures per ton of metal.

The technical and economic analysis of the production costs of various types of production cannot be confined to the examination of the periods of the year (quarter, month) during which various changes in production cost have occurred, and the links of technological process in which these changes have occurred. In every individual case, it is necessary to resolve an additional question, namely, which expenditure items and what factors were responsible for the rise or decline in the production cost of a product.

"For a rational guidance of the activities of enterprises," declares the Resolution of the 18th Party Conference, "it is necessary to be familiar with the actual expenditures per product unit according to the principal elements of production cost -- wages, cost of raw material, fuel and electrical energy, amortization deductions, administrative-managerial expenditures -- and to orient the economic aspect of the activity of enterprises so that the plans of production cost and profit would be unconditionally fulfilled."

Every branch of industry has its own more or less characteristic structure of production cost showing which expenditure items are the most important to a given branch and indicating the principal sources harboring the potential for reducing production cost (Table 83).

Table 83

Structure of the Production Cost in Various Branches of USSR Industry in 1939* (in percent of the total)

Branch of Industry	Wages and Allowances	Raw and other Materials	Fuel and Electrical Energy	Amortization	Miscellaneous Expenses	Total
Black Coal Extraction	62.0	20.7	3.0	3.0	11.3	100.0
Ore Extraction	57.1	24.2	2.8	4.8	11.1	100.0
Oil Extraction	25.1	8.0	6.4	36.5	24.0	100.0
Ferrous Metallurgy	24.0	45.3	19.1	4.1	7.5	100.0

[Table 83 continued on next page]

/Table 83 continued from page 39/

Branch of Industry	Wages and Allowances	Raw and other Materials	Fuel and Electrical Energy	Amortization	Miscellaneous Expenses	Total
Chemistry	17.8	67.4	5.2	2.7	6.9	100.0
Cotton	16.3	77.1	2.8	1.1	2.7	100.0

* Sh. Ya. Turetskiy, "Planning of Production Cost," Gosplanizdat, 1941, page 27.

While in the coal and ore extracting branches the predominant expenditure item in the cost of production is the remuneration of live labor (wages and allowances), in the other branches of industry a larger share in production cost is taken up by the expenditures on materialized labor: raw and other materials in the chemical (67.4 percent) and cotton (77.1 percent) industries, and amortization in the oil extracting industry (36.5 percent), where mechanization is high and the wear of machinery is considerable.

In different branches an identical percentage of reduction in a given expenditure item will affect differently the over-all level of production cost. Thus, a 10-percent saving in raw and other materials reduces the production cost in the chemical industry by 6.7 percent, in the ore extracting industry -- by only 0.8 percent.

In nonferrous metallurgy the structure of expenditures in the ore-mining enterprises differs substantially from the structure in the metallurgical enterprises. This can be illustrated by the following data (Table 84).

Table 84

Structure of Production Cost (in percent of total)

	Wages and Allowances	Raw and Principal Materials	Auxiliary Materials	Fuel and Electrical Energy	Amortization	Miscellaneous Expenses	Total
Ore-Mining Enterprises	56.6	-	15.0	6.9	5.7	15.8	100.0

/Table 84 continued on next page/

[Table 84 continued from page 40]

	Wages and Allowances	Raw and Principal Materials	Auxiliary Materials	Fuel and Electrical Energy	Amortization	Miscellaneous Expenses	Total
Metallurgical Plant	18.8	60.6	8.3	6.7	1.7	3.9	100.0

The largest share, as shown by these data, in the ore-mining enterprises is taken up by the expenditures on wages and allowances (56.6 percent), while in the metallurgical enterprises it is taken up by raw and principal materials (60.6 percent). Depending on technological progress, the structure of expenditures in metallurgical plants has also peculiarities of its own. For instance, in the aluminum industry the cost of electrical energy accounts for 25 percent of the total of operating expenditures, in the nickel industry the expenditures on technological fuel account for approximately 25 percent of the total, and in the copper electrolysis plants the cost of the raw material accounts for over 90 percent of the total.

The structure of expenditures according to individual branches and to industry as a whole does not remain always stable and, in measure with the increase in the pool of equipment, rise in labor productivity and improvement in the indexes of production-economic activity, essential shifts may occur in the structure of production cost.

Thus, in the period from 1928/1929 to 1939 the following changes had occurred in the structure of expenditures of the Soviet industry as a whole (Table 85).*

Table 85

Changes in the Structure of Production Cost in the USSR Industry Between 1928/1929 and 1931 (in percent of total)

Index	1928/1929 rr.	1939 r.
Wages and Allowances	34.3	22.4
Material Expenditures, Including Amortization	55.6	72.0
Miscellaneous Expenditures (of Non-Production Character)	10.1	5.6
Total	100.0	100.0

*Sh. Ya. Turetskiy, "Planning of Production Cost," Gosplanizdat, 1941.

The figures cited in Table 85 indicate an increase in the share of material expenditures during that period, accompanied by a decrease in the share of wages, which is to be explained not only by the rise in raw material prices but also by the reduction in labor consumption of production as a result of the transition of industry to a higher technological level. This increase in material expenditures is also accompanied by a pronounced decline in the share of non-production expenditures as a result of the increase in volume of output, rationalization of management, and simplification of the industrial apparatus.

This is also confirmed by the changes in the share of material expenditures in the structure of production cost in the principal branches of the heavy industry (Table 86).*

Table 86

Material Expenditures in Percent of the Total Expenditures

Branch of Industry	1932 r.	1934 r.	1936 r.	1939 r.
Black Coal Extraction	18.1	17.4	22.3	26.7
Ferrous Metallurgy	48.2	49.7	64.4	68.5
Nonferrous Metallurgy	-	54.2	68.1	69.5
Machine Building	36.4	41.9	50.0	51.4
Chemical	54.0	63.1	65.5	76.3

2. Principal Factors Determining Production Cost

Production Cost and Labor Productivity

The increase in labor productivity is one of the most important sources of reduction of production cost in all branches of industry irrespective of the share of wages in the structure of production cost.

In the Soviet industry, the savings achieved by increasing labor productivity during the Second Five-Year Plan had amounted to 48-50 billion rubles, of which over 28 billion were utilized for wage raises. The reduction of production cost is achieved by advancing the rise in labor productivity at a faster pace than the rise in wages.

* Sh. Ya. Turetskiy, "Planning of Production Cost," Gosplanizdat, 1941, page 55.

The relationship between the reduction of the production cost per output unit and the paces of rise in labor productivity and rise in average wage is determined by the following formula:

$$X = \left(100 - \frac{100 \cdot J_z}{J_t}\right) \cdot y$$

where X is reduction of production cost, in percent;
J_z is index of mean worker wage (ratio of wage paid in the analyzed period to wage paid in the preceding year, in percent);
J_t is index of labor productivity; and
y is share of wages in the structure of production cost in the preceding year.

Example. When labor productivity rises 15 percent, mean wage rises six percent, and the share of wages in production cost rises 20 percent, the decline in the expenditures on wages per output unit will amount to:

$$X = 100 - \frac{100 \cdot 106}{115} = 8 \text{ percent.}$$

The reduction of the production cost per output unit will be:

$$X = \frac{8 \cdot 20}{100} = 1.6 \text{ percent.}$$

The influence of the wage total on the production cost of output is determined by the ratio of the rise in the general wage fund to the rise in the volume of output, and by the share of wages in production cost.

Thus, if the wage fund grows 10 percent and the volume of output grows 25 percent, then, when the share of wages in production cost amounts to 50 percent, the total reduction in production cost because of the wages will amount to:

$$X = \left(100 - \frac{100 \cdot 100}{125}\right) \cdot 0.5 = 6 \text{ percent}$$

Production Cost and Material Expenditures

The cost of the raw material consumed per output unit consists of two elements: consumption norm and the current price of the raw material.

Consumption norm, in turn, depends on the quality and degree of utilization of the raw material and on the type of

the fabricated semifinished or finished product.

The higher the content of metal [in ore], the smaller amount of raw material is consumed per ton of metal, and conversely, the less metal-rich the raw material the higher its consumption norm per ton of output.

The following simple calculation could be cited:

	First Example	Second Example
Content of metal in ore, in percent	1.0	5.5
Amount of ore containing one ton of metal, in tons	100.0	18.2

The other factor affecting the unit consumption of the raw material is the efficiency of its industrial utilization.

The fuller the recovery of metal from the raw material or, in other words, the lower the in-production losses of metal, the lower the consumption of the raw material per output unit.

This may be illustrated by the following data:

	First Example	Second Example
Content of metal in ore, in percent	1.0	5.5
Recovery of metal, in percent	70.0	91.0
Content of recoverable metal in ore, in percent	0.7	5.0
Amount of ore needed to smelt out one ton of metal, in tons	143.0	20.0

It is utterly obvious that, in the first example, the processing of 143 tons of ore will cost several times as much as, in the second example, the processing of 20 tons. Operation with low-grade ore requires (in per-ton-of-metal terms) much higher material expenditures than does the processing of metal-rich ore, both on the sector of beneficiation (flotation agents, grinding materials, electrical energy, etc.) and on the sector of metallurgical reduction (fluxes, fuel, electrical energy, etc.). It is sufficient to mention that if the consumption of electrical energy for beneficiating one ton of ore is assumed at 30 kwh, then the processing of 143 tons of ore at the concentrator plant will consume 4,290 kwh, while the processing of 20 tons -- only 600 kwh.

In the metallurgical process, which involves the consumption of fluxes equal to 25 percent of ore by weight, the total amount of charge to be processed will amount to 143 + 36 = 179 tons in the first case, and 20 + 5 = 25 tons in the second case.

It is clear that the greater the amount of charge processed to obtain one tone of metal the greater the consumption of technological fuel, electrical energy, auxiliary materials, and human labor.

The third factor affecting the unit consumption of raw materials is the type and quality of the processed product (concentrate, finished metal).

The more metal-rich the processed product the higher -- all other conditions remaining equal -- the index of consumption of raw material per ton of the product.

Thus, the interrelationship of factors determining the quantitative norm of consumption of raw material could be expressed by the following formula:

$$F = \frac{M}{f \cdot E} \cdot 100,$$

where: F is quantitative consumption of raw material per ton of product, in tons;
M is content of metal in the product, in percent;
f is content of metal in the raw material, in percent;
E is recovery of metal from the raw material into the product, in percent.

The calculation of the cost of the raw material is based on the price established per ton-percent of metal in ore and in concentrates and other semifinished products.

According to the concrete content of metal, the prices per ton-percent are differentiated, and therefore the cost of one ton of metal in the raw material will differ from the cost for the metal in the semifinished products. Thus, if the price per ton-percent of metal in an ore amounts to six rubles, and per ton-percent of metal in the concentrate -- 15 rubles, then one ton of metal in ore will cost 600 rubles, and in the concentrate -- 1,500 rubles.

In nonferrous metallurgy, where an enormous quantity of ores is processed, the retreatment of production wastes can serve as a major factor in reducing the consumption norms of raw materials.

The prices for the purchased materials, fuels and electrical energy are a factor which does not depend on the enterprise, and they change independently of the enterprise's production activity.

Inasmuch as production expenditures are, in the final analysis, calculated for the finished product, therefore it is necessary always to keep in mind that when the content of metal in the starting raw material varies then the material expenditures per ton of metal may fluctuate quite broadly. Thus, to return to the previously cited examples in which

the need for ore per ton of metal was calculated in 143 and 20 tons, respectively, with the fuel consumption norm (five percent of the weight of the raw material) being the same in both cases, we find that the consumption of fuel per ton of finished metal is seven tons in the first case and one ton in the second.

Deviations from the established norms of material and fuel consumption in production may stem from many causes.

Consumption indexes are adversely affected by: low quality of materials and fuel, infractions of technological regime, insufficient control of the consumption of material means, low quality of grinding materials (grinding balls, rods) in concentrator plants, poor grades of fluxes used in metallurgical processes, high percentage of ash and moisture in technological fuel, excessive fines in the coke burned in shaft furnaces. All this inevitably deteriorates the performance of equipment and often leads to overconsumption of materials.

Substantial savings in the consumption of fuel are yielded by the utilization of the heat of the furnace waste gases. It is known, e.g., that the reverberatory furnaces of the copper smelting plants utilize only 25 percent of the heat released by the burning of fuel, or when with steam heat recovery boilers, 35-40 percent.

The establishment of a stable production regime and the strict observation of technological discipline are the most important premises for a proper and economical utilization of material means.

In the shops where a great amount of returns happens because of technological shortcomings, and particularly in the shops with a high percentage of rejects, the retreatment of the returns and rejected products definitely improves the consumption indexes.

In the plants conducting the processes of electrolysis, restrictions imposed by electric power stations and irregular supply of electricity may violate the rhythm of production, deteriorate the current yield index and, in the final analysis, lead to an overconsumption of electrical energy per metal unit.

In every industrial enterprise the efficient utilization of material means is predicated on a properly organized accounting and control as an inseparable part of the organization of production and the paramount problem of the economic-technical management of the enterprise.

Considering that material expenditures in the calculations may vary both on account of consumption norms and on account of prices, the technical-economic analysis of production cost can reveal the relative importance of each of these factors and by the same token throw light on the role

of the enterprise in the struggle for reducing production cost.

To clarify such an analysis, let us examine the following numerical example (Table 87).

Table 87

Expenditures per Output Unit in the Reference Period and in the Period Under Analysis

Kind of Expenditure	Reference Period			Period Under Analysis		
	Quantity of Output	Price, rubles --kopeykas	Total Amount in rubles	Quantity of Output	Price, rubles --kopeykas	Total Amount in rubles
Raw Material	50 tons	20-00	1000	60 tons	15-00	900
Fuel	3	60-00	180	2	60-00	120
Electrical Energy, in kwh	500	0-08	40	550	0-06	33
Total	-	-	1220	-	-	1053

In the above example the cost of material expenditures per output unit declined, ultimately, by 1,220--1,053 = 167 rubles.

To determine the influence of the quantitative and value factors on the obtained result, let us utilize the following auxiliary calculation.

Expenditures According to Norms for the Period Under Analysis and Prices in the Preceding Reference Period

	Quantity	Price, rubles --kopeykas	Total Amount, in rubles
Raw Material	60 tons	20-00	1200
Fuel	2	60-00	120
Electrical Energy	550 kwh	0-08	44
Total	-	-	1364

It follows from the above calculation that if the prices during the analyzed period remain stable, on the level of the preceding period, then the cost of material expenditures will amount to 1,364 rubles, i. e., the changes in consumption norms should lead to an increase of 1,364--1,220 = 144 rubles compared with the preceding period. Actually how-

ever the total of expenditures has not increased but, conversely, it has declines by 1,220--1,053 = 167 rubles.

On the basis of all these data, the following conclusions may be made.

(a) As a result of the changes in consumption norms, expenditures rose by 1,364--1,220 = rubles;

(b) As a result of the changes in prices, expenditures dropped by 1,364--1,053 = 311 rubles;

(c) In the final analysis, the cost of material expenditures declined by 1,220--1,053 = 167 rubles.

Hence it follows that, despite the existing savings, the above-cited dynamics of expenditures cannot be regarded as satisfactory, because the consumption indexes (shop-dependent factor) became worse and the entire reduction was obtained solely as a result of changes in prices (independent factor).

Speaking of prices as a factor independent of the enterprise, it is nevertheless necessary to keep in mind that in every individual case this question requires a special examination, because the consuming plant could take a number of measures purporting to reduce the cost of the purchased materials. Such measures include: utilization of local types of fuel and materials in lieu of those imported from afar, transition to less expensive means of transport (water transport in lieu of rail transport), substitution of expensive materials by cheaper ones without harming the quality of production, rationalization of the operations concerned with the unloading and conveyance of materials to plant depots, etc.

Production Cost and Amortization

The principal factors determining the share of amortization in the production cost per output unit are as follows:

(a) Degree of mechanization of production and value of fixed assets;

(b) Rate /percentile/ of amortization deductions, which depends on the service life of equipment;

(c) Degree of utilization of equipment -- volume of fabricated output.

The interrelationship of these factors is perfectly obvious. The higher the value of fixed assets and the higher the rate of amortization deductions, the greater amount of deductions per product unit, and conversely the greater the volume of output the smaller the amount of amortization deductions per ton of product.

Production Cost and Volume of Output

Volume of output is one of the principal factors in reducing production cost.

An analysis of the individual expenditure items shows that changes in the volume of output affect differently the different expenditures in their absolute totals.

From this standpoint, we distinguish between:

(a) Fixed expenditures, and

(b) Proportional expenditures.

Fixed expenditures are those which remain unchanged, in their absolute figures, at changes in the volume of output or at any rate those which do not rise to the same extent as the volume of output.

In the production cost per output unit, fixed expenditures change in inverse proportion to the volume of output.

Fixed expenditures include, e. g.: salaries of the administrative-managerial personnel, current repairs of buildings, heating and lighting of premises, /salaries of7 guard personnel, office expenses, etc.

As for proportional expenditures, these change in absolute figures in direct proportion to the volume of output, and account for a more or less fixed share in the cost per output unit.

The group of proportional expenditures may include: upkeep and repair of machinery, installations and other production equipment, expenditures on intra-shop transport, motive power for production purposes, etc.

The relationship between the changes in fixed and proportional expenditures and the changes in the volume of output may be illustrated by the following nominal example (Table 88).

Table 88

Change in Fixed and in Proportional Expenditures, in rubles, According to Change in Volume of Output

Volume of Output, in tons	Absolute Magnitude of Expenditures		Expenditures per Output Unit		Total per Output Unit
	Fixed	Proportional	Fixed	Proportional	
1 000	80 000	50 000	80	50	130
2 000	80 000	100 000	40	50	90
4 000	80 000	200 000	20	50	70

The above-cited figures should be regarded only as nominal quantities characterizing solely the general trend of these groups of expenditures. Actually, both the fixed and the proportional expenditures change not only according to volume of output but also according to a large number of technical and organizational factors related to the rationalization of processes, improvement in the management of industry, etc.

3. Production Cost and Comprehensiveness of Utilization of Raw Material

In nonferrous metallurgy the comprehensive processing of the ore raw materials constitutes a tremendous but actually still little utilized potential for reducing production cost.

Inasmuch as the ores of nonferrous metals are, as noted before, in their overwhelming majority, polymetal ores, therefore their comprehensive processing ensures not only the production of one or two principal metals but also the concomitant recovery, from the same raw material, of secondary components valuable from the national-economic standpoint.

The comprehensive method of raw material processing can yield an enormous economic effect in terms of both the quantitative and, particularly, qualitative indexes of performance of the enterprise. The effectiveness of this method is expressed in the following:

(a) The number of components recoverable from one and the same raw material becomes larger;

(b) The index of recovery of the principal metal increases as a result of the retreatment of production wastes;

(c) Higher purity and better quality of the finished product are ensured, as a result of the elimination of side components therefrom;

(d) Production cost is cut considerably, because the cost of the raw material and many of the expenditures on its processing can be divided among all the processed components.

The practice of nonferrous-metallurgy enterprises is replete with examples confirming the above postulates. Thus, a concentrator plant in Altay, which processes polymetal ore, has mastered copper flotation and begun to produce copper concentrates in addition to its usual lead and zinc concentrates.

This measure yielded the following effect:

(a) For every 1,000 tons of ore the plant began to obtain 40 tons of copper concentrates <u>in addition</u> to the previously produced 200 tons of lead and zinc concentrates,

i. e., the total yield of concentrates has increased by 20 percent;

(b) Lead concentrates, which had previously contained a substantial amount of copper, began to be obtained in a purer form, unpolluted by copper, after the mastering of copper flotation, and this in turn has considerable facilitated and improved the process of lead smelting at the metallurgical plant;

(c) The division of expenditures on the extraction and processing of ore among three concentrates instead of two resulted in a sizable reduction in the production cost of the concentrates.

In the copper industry, the use of gold-bearing fluxes in plants has recommended itself as a very effective measure, because the joint smelting of copper and gold leads to a substantial decline in the cost of both metals. The side recovery of gold in the plants of the copper industry is the cheapest of all the methods of obtaining gold.

B. Compiling the Plan of Production Cost

1. Drafting of Planned Calculations and Estimates of Overhead Expenses

The plan of production cost is compiled in accordance with the goal set by superior authorities. The targets as to production cost are stipulated: for comparable output -- in the form of percentile reduction in the production cost of marketable output; and for non-comparable output -- in the form of estimated production cost per output unit.

To compile the plan of production cost, it is necessary to:

(a) Compose planned calculations of the individual types of products, and an estimate of overhead expenditures;

(b) Calculate the reduction in the production cost of marketable output (determine the percentage of reduction and the total amount of savings);

(c) Compose estimates of production by individual shops and by the enterprise as a whole.

A typical calculating sheet blank contains the following headings and items:*

*Cf. "Guide to the Standard Plan for Calculating the Basic Activities of the Economic Organizations of Heavy Industry," GONTI, Moscow, 1938.

Calculating Blank

Heading and Item	Quantity	Price	Total Amount
A. Basic Production Expenditures			
I. Materials			
1. Raw and Principal Materials			
2. Auxiliary Materials			
II. Technological Fuel			
III. Energy Expenditures (for Technological and Motive-Power Purposes)			
1. Electrical Energy			
2. Steam			
3. Compressed Air			
4. Water			
Total, Item III			
IV. Wages and Allowances (for Blue-Collar workers)			
1. Basic Wage			
2. Additional Wage			
3. Fringe Benefits			
Total, Item IV			
V. Amortization (Depreciation of Value) of Fixed Assets of the Shop			
VI. Compensation for the Wear of Low-Value and Rapidly Wearing Tools, Production Facilities and Replaceable Equipment			
VII. Miscellaneous Basic Expenditures			
B. Overhead Production Expenditures			
VIII. Current Repair of Fixed Assets of the Shop			
IX. Upkeep of Fixed Assets of the Shop			
X. Transport of Loads			
XI. Labor Safety			
XII. Shop Overhead Expenditures (Miscellaneous)			
Total, Shop Overhead Expenditures (Items VIII-XII)			
XIII. Plant-Wide Expenditures			
Total Production Cost (Concentrator Metallurgical Plants)			
XIV. Non-Production Expenditures			
Over-all Total (Commercial) Production Cost			

It follows from that blank that calculated expenditures are subdivided into two groups: (a) Basic production expenditures; and (b) Overhead production expenditures.

Each of these groups has its own structure and its own planning methodology.

Planning the Basic Production Expenditures

The basic production expenditures include the expenditures directly expended to materialize the technological process. The majority of these expenditures are stipulated in the plan not only in terms of value indexes but also in terms of norms of consumption per unit of the output being calculated.

Consumption indexes can be used to determine the qualitative aspect of the performance of the individual shops, the technical and organizational level of the enterprise's activities. They make it possible to compare the performance of one enterprise with that of other, analogous enterprises, and with the indexes of foreign industry. Every type of production has its own structure of basic expenditures hinging on the technology of production. In nonferrous metallurgy the principal items of basic expenditures are: in the ore-mining enterprises -- drilling-bit steel, hard alloys, explosives, timbering (when certain mining systems are employed), electrical energy, compressed air, and wages; in the concentrator plants -- ore, sands, steel balls and rods, lining, flotation agents, filtering fabric, electrical energy, water, and wages; in the metallurgical plants -- ore, concentrates, fluxes, fuel, electrical energy, wages, etc.

The problem of planning basic expenditures is reduced primarily to determining the right norms of consumption per output unit for every type of production and, at the same time, determining the consumption indexes for the principal stages of the technological process.

When determining the consumption norms, it is necessary to take into account all the utilizable potential uncovered by analyses of the actual performance of the enterprise, and at the same time to consider the organizational and technical measures intended to improve the technological process and the qualitative indexes of performance.

To formulate explicitly the targets as to consumption indexes, it is necessary always to stipulate the accounting units in which the consumption norms are set (per cubic meter of mined mass, per ton of ore or charge, per ton of metal, etc.) and the measurement units in which the norms are calculated (kilogram, ton, piece, meter, etc.).

Every consumption norm should be based on calculation and should be technically and economically justified.

The consumption of raw materials per ton of product in nonferrous metallurgy is, as noted before, determined by the content of metal in the starting raw material, content of metal in the released product, and recovery of metal from the raw material into the product. For instance, if the content of metal in an ore is 3.5 percent, the content of metal in the concentrate -- 15 percent, and the recovery of metal at the concentrator plant amounts to 87 percent, then the consumption of ore per ton of concentrate will be:

$$\frac{14 \cdot 100}{3.5 \cdot 87} = 4.6 \text{ tons}$$

The consumption of concentrates (14 percent Cu) per ton of finished pure metal (100 percent) will be expressed in the following figures if the recovery at the plant amounts to 93 percent:

$$\frac{100}{14 \cdot 93} = 7.7 \text{ tons}$$

The unit consumption of fluxes depends on the desired composition of slags and the quality of raw materials and fluxing materials, and it is determined by a special metallurgical calculation. At the same time every metallurgical plant sooner or later tends to establish its own fixed unit consumption of fluxes, calculable in percent by weight of the processed charge.

The consumption of technological fuel in a number of branches of nonferrous metallurgy is also measured in percent by weight of solid charge, in which connection the norm of consumption varies fairly broadly depending on the production process. Thus, in the copper industry, fuel consumption in copper blast furnaces amounts to: for pyrite smelting -- three percent by weight of charge; for semipyrite smelting -- four-10 percent by weight of charge; for reverberatory-furnace smelting -- 13-18 percent; and the consumption of coke during the smelting of lead in lead blast furnaces amounts to 10-15 percent by weight of charge.

The determination of the consumption norms for electrical energy is of a particularly great importance for such energy-consuming processes as flotation, electrolysis of copper and zinc, and, especially, production of aluminum and magnesium.

In the aluminum industry, the unit consumption of electrical energy is inversely proportional to the index of

the energy yield of metal.

Thus, if the index of energy yield amounts to 56 grams per kwh, then the consumption of electrical energy per ton of aluminum will be:

$$\frac{1}{56} \cdot 1000 \cdot 1000 = 17\ 850 \text{ kwh}$$

The consumption of blue-collar manpower per unit of finished output is calculated in man-hours and determined by dividing the number of man-hours worked by blue-collar workers by the total amount of the produced output.

Technical-economic consumption indexes are calculated for both the basic shops producing finished output and the shops producing semi-finished products, electrical energy, steam, compressed air, etc.

To illustrate the planning of unit consumption, let us cite two examples (Tables 89 and 90).

Table 89

Consumption Indexes per Ton of Ore for the Flotation Process

Subject	Unit of Measurement	Previous Report Year	Planned Year
Steel Balls....................	kg	1.10	1.0
Cores..........................	"	0.4	0.35
Xanthate.......................	"	0.075	0.065
Pine Oil.......................	"	0.04	0.03
Copper Sulfate.................	"	0.75	0.70
Lime...........................	"	3.0	2.5
Filtering Fabric...............	m	0.012	0.01
Electrical Energy..............	kwh	35	30
Water..........................	m^3	5.0	4.0
Manpower.......................	man-hours	0.6	0.5

Table 90

Consumption Indexes per Ton of Blister Copper for Metallurgical Smelting

Subject	Unit of Measurement	Previous Report Year	Planned Year
Concentrates..................	tons	8.0	7.6

/Table 90 continued on next page/

/Table 90 continued from page 55/

Subject	Unit of Measurement	Previous Report Year	Planned Year
Quartz	tons	3.4	3.3
Fuel	"	2.2	2.0
Electrical Energy	kwh	600.	540.
Steam	tons	0.20	0.15
Water	m3	20.0	18.0
Manpower	man-hours	22.0	19.6

The established consumption indexes are used for two purposes: to compose planned calculations of basic expenditures, and to calculate the needs of the enterprise for material supplies.

The drafted consumption norms correspond with planned prices which should serve as the basis for calculating the cost of basic expenditures on the calculating sheet. When calculating the planned prices it is necessary to consider the purchase prices in which the accounting with the purveyors will be settled and, separately, the transport expenditures involved in delivering the raw or other materials to the site of demand.

Planning the Overhead Production Expenditures

Overhead expenditures include expenditures relating to the organization, servicing and administration of production, and the expenditures intended to create the necessary conditions for materializing production processes.

Basic expenditures can be calculated in quantitative measurement units directly relating to the fabrication of a given type of product, whereas overhead expenditures are included indirectly, through redistribution, into the production cost of individual types of production.

The structure of overhead production expenditures includes the following groups of expenditures: (a) shop overhead expenditures; (b) plant-wide expenditures; and (c) non-production expenditures.

(a) Shop Overhead Expenditures

1. Current repairs of fixed assets of the shop;
2. Upkeep of fixed assets of the shop;

3. Transporting of loads;
4. Labor safety;
5. Wages of shop personnel (engineers and technicians, white-collar workers, MOP /junior maintenance personnel/);
6. Wages of workers (those not included in basic expenditures);
7. Fringe benefits;
8. Guarding of premises;
9. Repair, maintenance and renovation of low-value and rapidly wearing tools, attachments and inventory;
10. Office Expenses;
11. Business trips;
12. Experiments, tests and investigations;
13. Expenditures on rationalization;
14. Deductions to the fund for invention and technical improvements;
15. Expenditures during work stoppages;
16. Expenditures not specified in the preceding items (examination of white- and blue-workers to determine their skills, finer packaging of output, etc.).

(b) Plant-wide Expenditures

I. Administrative Expenditures

1. Salaries of administrative personnel (basic and additional);
2. Fringe benefits;
3. Promotions;
4. Business trips
   REMARK: Business trips made to procure materials are included in the cost of materials;
5. Maintenance and use of light transport /chauffeured cars/;
6. Office, postage and telegraph expenses;
7. Maintenance of buildings, premises and inventory of plant administration;
8. Penalties for infractions of rules of document turnover;
9. Miscellaneous administrative expenditures.

II. General Production Expenditures

10. Maintenance of buildings, structures and inventory;

11. Current repairs of buildings, structures and inventory;
12. Maintenance of facilities for storing finished output;
13. Maintenance of material storage facilities;
14. Amortization;
15. Expenditures of plant-wide character on rationalization and inventions;
16. Maintenance of plant laboratories and expenditures on testing and research;
17. Recruiting of labor force;
18. Labor safety;
19. Wages of industrial trainees and expenditures on the continuous practice training of students;
20. Expenditures on special types of protection of the enterprise;
21. Miscellaneous general production expenditures.

III. Obligatory Deductions and Expenditures

22. Taxes and fees;
23. Deductions to the fund of inventions and technical improvements;
24. Expenditures made on the order of the concerned Ministry;
25. Miscellaneous expenditures.

(c) Non-Production Expenditures

Non-production expenditures consist of:
1. Deductions for the centralized financing of scientific-research work;
2. Maintenance of depots and transfer points outside the plant;
3. Cost of the loading and transporting of output to marketing sites.

The work on the planning of overhead expenditures is done in two stages: drafting of the estimates of (shop, plant-wide and non-production) overhead expenditures, and division of shop expenditures among individual types of production, and plant-wide expenditures among individual shops.

During this work every item of overhead expenditures should be determined on the basis of the accounting for every type of expenditure.

Every item in the estimate of expenditures of principal shops should be tied to a corresponding item in the estimate

of expenditures of auxiliary shops. Thus, the consumption of electrical energy should correspond fully with the plan of the output and distribution of electrical energy; the consumptions on current repairs should correspond fully with the production program of the repair shop; and the expenditures on heating, lighting, water supply and sewerage should correspond fully with the plans of the concerned auxiliary shops.

The calculation of amortization should be based on the cost of fixed assets and on the appropriate rate of amortization deductions. The calculation of the production costs of auxiliary types of production (electrical energy, steam, compressed air, etc.) should precede the compilation of the estimates of overhead expenditures and the drafting of the over-all estimate of output for the shop or enterprise.

Shop and plant-wide expenditures are divided by the following procedures:

(a) In proportion to the total amount of basic expenditures minus the amount of extra payments made according to the progressive-bonusing piecework pay system;

(b) In proportion to the number of machine-hours of operation of individual assemblies;

(c) In proportion to the cost of an operation, on deducting the cost of raw materials and semifinished products and the extra piecework bonus payments.

When dividing shop expenditures among the individual types of production it is necessary to utilize the possibility of localizing the individual expenditure items, i. e., to establish the quantitative relationship between these items and fixed indexes. For instance, amortization deductions and current repair of equipment depend directly on the value and state of fixed assets, transport expenditures depend on the amount of transported cargo, heating expenditures depend on the size of premises, fringe benefits depend on the wage fund, etc.

Thus, whenever it is feasible to localize expenditures according to individual equipment assemblies or individual production sectors the concerned expenditures should be deducted from the total amount of shop expenditures and transferred directly to the concerned equipment assembly or production sector.

To clarify the results of the activity of economic-accounting shops, the related calculations are based on the economic-accounting production cost, in which the expenditures dependent on the performance of the shop are indicated according to actual data, while the planned expenditures are indicated according to planned norms.

In the economic-accounting calculation of a shop, the

expenditures per output unit are deduced in the following manner:

(a) Actual consumption of raw and other materials, fuel, semi-finished products, and services, is calculated according to planned prices;

(b) Additional wages and fringe benefits are calculated in planned percent of the actual total amount of basic wage;

(c) Plant-wide expenditures are calculated in absolute figures, to be financed by the shop's industrial-financial plan.

(d) The remaining expenditure items are calculated according to the actual total of expenditures.

A comparison of economic-accounting calculation with the planned calculation indicates what if any deviations from the stipulated production cost are perpetrated by the shop, and what operative measures should be adopted to eliminate the work shortcomings.

Calculating the Production Cost of Ore Extraction

In the ore-mining industry, which involves extremely labor-consuming processes, labor productivity is a decisive factor both to the volume of output and the production cost. The type of mining system employed is particularly important among the principal factors affecting labor productivity. The analysis and drafting of calculations in an ore-mining enterprise should be made on taking account of the full importance of the effect of the mining system employed by that enterprise.

The ratio of the cost of mining to the mining system used is expressed by the following relative figures in the American ore mines:*

Square set with fill..............	100.0
Fill working......................	81.0
Shrinkage stoping.................	64.0
Top slicing.......................	29-50.0
Sublevel caving...................	25.0
Open stoping......................	22.0
Block caving......................	10.0

According to practical data the relationship between the direct expenditures per ton of ore and the mining system

* "Tsvetnyye Metally," No. 5, 1938, article by N. S. Sindarovskiy.

used, in the Ural copper mines, is expressed by the following relative indexes:

Systems with propping and filling.....	100.0
System of horizontal layers with filling...........................	80.0
Top slicing...........................	52.0
Sublevel caving........................	43-50

The mining system used influences not only labor productivity and manpower expenditures but also material expenditures. The systems with propping and filling require larger material expenditures than do the other mining systems and inevitably result in a higher-costing ore. However, their use is justified by the smaller risk of underground fires and lower percentages of losses and degradation of ore compared with the other systems. From the standpoint of the consumption of drilling steel, the use of hard alloys for drilling is of enormous importance.

The effectiveness of drilling by hard alloys is illustrated by the following data (Table 91).

Table 91

Effectiveness of Drilling by Hard Alloys*

Index	Kochkar'-Zoloto (hard granite)		Sokol'nyy Mine in the Altay (hornstone)	
	Hardened Bit	/Bit/ With Hard-Alloy Coating	Hardened Bit	/Bit/ With Hard-Alloy Coating
Performance per bit until it is dulled, in running meters	0.25	6.5	0.13	2.13
Drilling productivity, in running meters per hour	1.5	3.0	1.8	4.2
Consumption of drilling bits per hole-meter, in units	4.0	0.15	7.7	0.47

* B. M. Vasil'yev, "Ore Mining," 1939.

It follows from the above figures that the consumption

of drilling bits coated with hard alloys will be 16-27 times smaller than that of the merely hardened bits.

By way of other examples let us examine the calculations for the principal sectors of activity -- extraction, beneficiation and metallurgical reduction of ore (Table 92).

Table 92

Approximate Calculation of Production Cost per ton of Ore

Expenditure Item	Quantity	Price (Rubles--kopeykas)	Total Amount (Rubles--kopeykas)
Basic Expenditures			
Propping Materials, in m^3	0.057	97-94	5-58
Explosives, in kg	0.234	1-70	0-40
Bickford fuze, in meters	0.946	0-17	0-16
Detonators, units	0.636	0-14	0-09
Bit steel, in kg	0.026	0-95	0-03
Hard Alloys, in grams	0.7	0-30	0-21
Sundry materials	-	-	0-07
Total, Materials	-	-	6-54
Electrical energy, in kwh	7.56	0-07	0-53
Compressed air, in m^3	8.00	0-05	0-40
Wages of blue-collar workers, in man-hours	3.5	-	10-50
Additional wages	-	-	1-11
Allowances	-	-	1-16
Amortization	-	-	1-10
Dressing of bits	-	-	0-69
Depreciation of mine-development work	-	-	0-50
Total, Basic Expenditures	-	-	22-53
Overhead Expenditures			
Current repair	-	-	0-47
Upkeep of fixed assets	-	-	0-64
Transporting of loads	-	-	0-37
Labor safety	-	-	1-40
Miscellaneous overhead expenditures	-	-	4-43
Total, Overhead Expenditures	-	-	7-31
Shop production cost	-	-	29-84
Combine-wide expenditures	-	-	1-16
Combine-wide production cost	-	-	31-00

To compose the planned calculation of the cost of one ton of ore it is necessary to attend to the following:

(a) Determine the concrete consumption indexes for the basic expenditures (propping and explosive materials, bit steel, hard alloys, etc.);

(b) Establish the planned prices for the materials, energy, etc., consumed in production;

(c) Determine on the basis of the planned numbers of labor force the number of man-hours worked, the wage fund, manpower outlay, and magnitude of wage per ton of ore;

(d) Divide the cost of the various services furnished by the auxiliary shops (compressed air and electrical energy, dressing of drill bits, etc.) among the stoping, mine-development and capital mine construction operations. The cost of these services is subdivided in proportion to the volume of mined mass (in m^3) extracted in each of these groups of operations;

(e) Determine the amount of the amortization of mine-development work for the planned year.

The amortization of mine-development work is calculated by the following method:

	Reserves Prepared for the Beginning of the Year	Reserves to be Prepared for the Planned Year	Volume of Extraction Envisaged for the Planned Year	Reserves Prepared at the End of the Year
Amount of Ore, in thousands of tons	300	440	340	400
Cost, in thousands of rubles	150	220	170	200

Thus, when the expenditures on mine development work amount to 220,000 rubles, the calculation for the planned year is based on 170,000 rubles (or 50 kopeykas per ton) and the difference of 220,000-170,000 = 50,000 rubles is transferred to the balance sheet for increasing the account of expenditures for the subsequent year.

In the open-strip ore mines the amortization of overburden-stripping work is calculated on the basis of the ratio that has established itself between overburden stripping and extraction. Thus, if it is necessary to strip two m^3 of overburden per ton of ore, then the cost of stripping two m^3 of overburden will be included in the production cost per ton of ore in the regular order of amortization.

(f) Draft an estimate of overhead (shop and mine-wide)

expenditures and relate them commensurately to the stoping and mine-development operations.

When composing the plan of expenditures on mine-development and mine-construction work it should be taken into account that the side-extracted ore is appraised according to the estimated cost of stoping extraction (without considering the cost of the amortization of mine-development work) and entered in the accounting to reduce the expenditures on mine-construction and mine-development work.

Calculating the Production Cost of Concentrates

The production cost of concentrates consists of two elements: the cost of the raw materials consumed to produce concentrates, and the cost of the beneficiation of raw materials. The concumption of ore per ton of concentrate depends on the degree of concentration of metal during beneficiation and on the percentile recovery of metal from the raw material into the concentrate. The degree of concentration shows how many times is a concentrate richer than the ore or sands in its content of metal, and it is determined from the ratio of the percentile content of metal in the concentrate to that of metal in the processed raw material. The higher the degree of concentration the more efficient the process of beneficiation, but also the greater the quantitative consumption of ore per ton of concentrate.

Degree of concentration varies very broadly in various branches of nonferrous metallurgy, and therefore the unit consumption of raw materials for concentration may be expressed in very broadly varying figures.

Such variations can be perceived from the following fact: while in the copper and zinc industries the concentrate is approximately five to ten times richer than the ore, in the tungsten industry it is 120 and even more times richer. Such are the variations in the degree of concentration. The degree of recovery, on the other hand, affects the unit consumption of raw materials in an opposite manner: the higher the index of recovery of metal the greater the corresponding decrease in the unit consumption of raw material, when degree of concentration remains the same.

The unit consumption of raw material (x) could be determined by the following formula:

$$x = \frac{\text{degree of concentration}}{\text{index of recovery}}$$

Thus, the consumption of raw materials may increase

either because of an increase in degree of concentration (positive fact) or because of a decrease in the index of recovery (negative fact).

To clarify, let us cite the following example (Table 93):

Table 93

Relationship Between Ore Consumption and Degree of Concentration

	Concentrator Plant No. 1	Concentrator Plant No. 2
Content of metal in ore, in percent	2.0	2.0
Content of metal in concentrate, in percent	10.4	14.0
Degree of concentration	5.2	7.0
Index of recovery	0.80	0.87
Ore consumption per ton of concentrate, in tons	6.5	8.0

The unit consumption of ore at the concentrator plant No. 2 (eight tons) is higher than at the concentrator plant No. 1. However, the plant No. 2 operates with substantially better indexes with regard to both quality of concentrate and recovery of metal into concentrate, and all the technical and economic advantages are on its side.

Considering that the unit consumption of raw materials varies so broadly in various plants, the production cost of concentrate is a variable quantity which does not characterize the performance of the concentrator plant. Therefore, it is rather the cost of concentration per ton of ore that serves as the accounting unit for the concentrator plant (Table 94).

The calculation of the cost of concentration of one ton of ore is based on the basic expenditures calculated in accordance with the adopted indexes of consumption of materials and energy and with the established prices for these.

Overhead expenditures should be taken from the estimate drafted for the concentrator plant for the planned period. To find the production cost per ton of concentrate it is necessary to know the cost of extraction or the purchasing cost of one ton of ore, the cost of concentrating one ton of ore, and the consumption of ore per ton of concentrate.

Table 94

Calculating the Cost of Processing One Ton of Ore at a Concentrator Plant

Expenditure Item	Quantity	Price	Total Amount
		Rubles--kopeykas	
I. Basic Expenditures			
Materials and Energy			
Steel balls........................	kg 1.0	0-55	0-55
Steel rods.........................	kg 0.35	0-80	0-28
Lining.............................	kg 0.08	2-00	0-16
Xanthate...........................	kg 0.065	6-00	0-39
Pine oil...........................	kg 0.03	3-40	0-10
Copper sulfate.....................	kg 0.7	1-20	0-84
Lime...............................	kg 2.5	0-05	0-15
Filtering fabric...................	[running] meters 0.01	3-00	0-03
Electrical Energy..................	kwh 30	0-07	2-10
Water..............................	m^3 4.0	0-05	0-20
Total, Materials and Energy	-	-	4-80
Labor Force			
Basic wage.........................	-	-	0-80
Additional wage....................	-	-	0-08
Fringe benefits....................	-	-	0-08
II. Overhead Expenditures			
Current repair of fixed assets....	-	-	1-10
Upkeep of fixed assets............	-	-	0-84
Transport of loads................	-	-	0-50
Labor safety......................	-	-	0-16
Miscellaneous shop expenditures...	-	-	2-64
Total, Overhead Expenditures	-	-	5-24
Shop Production Cost (Headings I + II)........................	-	-	11-00
Plant-Wide Expenditures...........	-	-	1-00
Plant Production Cost.............	-	-	12-00

Thus, e. g., assuming that the cost of extraction of one ton of ore amounts to 31 rubles, the cost of its concentration -- 12 rubles, and the unit consumption of ore per ton of concentrate -- six tons, the production cost of one ton of concentrate will amount to:

Raw material. . . . . . . 31 x 6 = 186 rubles
Beneficiation . . . . . 12 x 6 = 72 rubles

Total production cost per ton of concentrate . . . . .258 rubles

Table 95

Calculating the Production Cost of One Ton of Blister Copper

Expenditure Item	Report Year			Planned Year		
	Quality	Price	Total Amount	Quantity	Price	Total Amount
		Rubles -- Kopeykas			Rubles -- Kopeykas	
	I. Basic Expenditures					
Raw Material([In this case]: Concentrates), in tons...........	-	278-00	2224	7.6	258-00	1961.0
Returns (gas for [transfer to] a chemical plant.	8	-	62.0	-	-	81.0
Fluxes (Quartz), in tons........	3.4	6-00	20.40	3.3	5-80	19.14
Fuel, in tons...	2.2	45.0	99.0	2.0	41.50	83.0
Electrical energy, in kwh.........	600	0.07	42.0	540	0.07	37.80
Steam, in tons..	0.20	8.0	1.60	0.15	7.0	1.05
Water, in m3....	20.0	0.06	1.20	18.0	0.05	0.90
Miscellaneous materials, in rubles.........	-	-	40.6	-	-	34.20
Remuneration of the Labor Force						
Basic wage, in man-hours......	22	-	46.2	19.6	-	44.10
Additional wage, in man-hours...	-	-	5.0	-	-	4.40
Fringe benefits, in rubles......	-	-	4.0	-	-	4.41
Total, Basic Expenditures...	-	-	2422	-	-	2109

[Table 95 continued on next page]

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Expenditure Item	Report Year			Planned Year		
	Quality	Price	Total Amount	Quantity	Price	Total Amount
		Rubles -- Kopeykas			Rubles -- Kopeykas	
	II. Overhead Expenditures					
Upkeep of fixed assets.........	-	-	11.0	-	-	10.0
Current repair of fixed assets	-	-	35.0	-	-	30.0
Transporting of loads...........	-	-	12.50	-	-	10.0
Labor safety....	-	-	5.0	-	-	5.0
Miscellaneous shop expenditures..........	-	-	71.5	-	-	55.0
Total, Shop Expenditures...	-	-	135	-	-	110.0
Amortization....	-	-	23.0	-	-	21.0
Plant-Wide Expenditures.....	-	-	110.0	-	-	90.0
Plant-Wide Expenditures...	-	-	2690	-	-	2330.0
In which: Cost of Processing /Metallurgical Reduction/.....	-	-	528	-	-	450
Smelting of metal, in tons.	28 600	-	-	33 250	-	-

Let us compare the planned and reported /actual, for the preceding period/ accounting for the principal expenditure items and pinpoint the factors causing a reduction in production cost.

The unit consumption of raw material (concentrates) for the planned year was computed on the basis of the following starting indexes: content of pure metal in blister copper -- 99 percent; content of copper in concentrates -- 14 percent; and total recovery /of copper/ for the shop as a whole -- 93 percent. Hence the consumption of concentrates per ton of blister copper will equal:

$$\frac{99 \cdot 100}{14.93} = 7.6 \text{ tons}$$

The consumption of quarts is determined according to the metallurgical computation of the charge.

The price of fuel will be cut to 41 rubles 50 kopeykas compared with 45 rubles in the preceding year, in connection with the intended utilization of the local types of fuel. The decline in the cost of fuel entails a decline in the cost of steam as well.

As for the calculation of the labor force, the plan takes into account a 12-percent rise in labor productivity and a seven-percent rise in wages. Commensurately, the expending of wages per output unit changes in the following manner compared with the preceding year:

$$\frac{46.20 \cdot 1.07}{1.12} = 44.10 \text{ rubles.}$$

The overhead expenditures per ton of metal will change on account of two factors: (a) envisaged 16-percent rise in smelting; and (b) five-percent reduction in the absolute sum total of shop expenditures and six-percent reduction in the absolute sum total of plant-wide expenditures compared with the preceding year. Hence, the change in overhead expenditures will be:

For shop expenditures $\frac{135}{1.16 \cdot 1.05} = 110$ rubles

For plant-wide expenditures $\frac{110}{1.16 \cdot 1.06} = 90$ rubles.

The change in the item of amortization deductions will stem from two factors:

(a) Five-percent increase in the value of property as a result of capital investments; and

(b) 16-percent increase in output.

Consequently, the scale of amortization deductions per ton of copper for the planned year will be:

$$\frac{23 \cdot 1.05}{1.16} = 21 \text{ rubles.}$$

As a result of the changes in expenditure items, the reduction of the production cost per ton of metal for the planned period is envisaged in the following figures (rubles) (Table 96):

Table 96

Plan of Reduction of Production Cost

Subject	Preceding, Reported Year	Planned Year	Total Savings	In percent of Preceding Year
Raw Material	2162	1880	282	- 13.0
Processing	528	450	78	- 14.8
Total	2690	2330	360	- 13.4

The foregoing calculations pertain to the processing of a monometal ore, from which one metal only is obtained. In cases of a comprehensive processing of a multi-component raw material which yields simultaneously a number of valuable components, the production cost is calculated by special methods. Let us illustrate these methods by individual examples.

2. Calculating the Production Cost of a Comprehensively Processed Raw Material

At the Concentrator Plant

A certain concentrator plant processes 100,000 tons of a polymetal ore with the following composition:

	Lead	Zinc	Copper	Gold
Content of metals in ore	3.5%	7.5%	1.0%	3 grams/ton
Gross content of metals	3,500 tons	7,500 tons	1,000 tons	3.0 kg

The processing has yielded the following quantities of concentrates from the 100,000 tons of ore:

	Quantity tons	Content of Metals			
		Lead tons	Zinc tons	Copper tons	Gold kg
Lead Concentrates	5,715	2,800	-	320	150
Zinc Concentrates	12,000	-	5,625	-	30
Copper Concentrates	1,600	-	-	400	60
Total, Recovered Metals	-	2,800	6,625	720	240

Only the components that can be recovered during the metallurgical processing of concentrates are taken into account in the calculations as part of the composition of concentrates. Thus, e. g., the zinc present in the lead and copper concentrates which will be lost during the processing of these concentrates, is not considered in the calculations.

When the cost of extraction of one tone of ore amounts to 35.5 rubles and the cost of its beneficiation -- 15.25 rubles, the total expenditures at the concentrator plant will amount to:

35.5 x 100,000 =	3,550,000 rubles
15.25 x 100,000 =	1,525,000 rubles
Total	5,075,000 rubles

The calculation of the production cost per ton of concentrate is conducted in the following order:

1. Proceeding from the (percentile) content of metals in ore and from the nominally adopted prices per ton-percent of metals in ore we find the respective share of the value of each metal in ore:

	Lead	Zinc	Copper	Gold	Total
Content of metals in ore	3.5%	7.5%	1.0%	3 g/ton	
Nominal price per ton-percent, in rubles -- kopeykas	2.00	1.50	4.50	3.50	
Value of metals in ore, in rubles -- kopeykas	7.00	11.25	4.50	10.50	33.25
Share of metal in value, in percent	21.1	33.8	13.5	31.6	100.0

2. We divide the production expenditures of the concentrator plant among the metals according to the respective share of each metal in the value of ore:

	Lead	Zinc	Copper	Gold	Total
Share in value, in percent	21.1	33.8	13.5	31.6	100.0
Plant expenditures, in thousands of rubles	1,071	1,715	685	1,604	5,075

3. Knowing the quantity of metals recovered into concentrates and the absolute sum of expenditures on every metal, we find the value per unit of every metal:

	Lead	Zinc	Copper	Gold
Quantity of metals recovered into concentrates	2,800 tons	5,625 tons	720 tons	240 kg
Expenditures on each metal, in thousands of rubles	1,071	1,715	685	1,604
Production cost per metal unit in concentrates, in rubles	382.5	304.9	951.4	6,684.0

4. Knowing the quantity of metals contained in each concentrate, and knowing the unit production cost of each metal, we divide the expenditures of the concentrator plant among the individual types of concentrates in the following manner:

	Lead	Zinc	Copper	Gold	Total
Lead Concentrates					
Quantity of Metal, in tons	2800	-	320	150	-
Value of Metals, in thousands of rubles	1071	-	304	1003	2378
Zinc Concentrates					
Quantity of Metal, in tons	-	5625	-	30	-
Value of Metals, in thousands of rubles	-	1715	-	200	1915
Copper Concentrates					
Quantity of Metal, in tons	-	-	400	60	-
Value of Metal, in thousands of rubles	-	-	381	401	782
Total Expenditures, in thousands of rubles	-	-	-	-	5075

5. Proceeding from the quantitative output of concentrates and the expenditures made on the individual types of concentrates, we find the production cost per ton of concentrates:

	Quantity Tons	Expenditures thousands of rubles	Production Cost per ton of Concentrates, in rubles
Lead Concentrates	5 715	2 378	416
Zinc Concentrates	12 000	1 915	159
Copper Concentrates	1 600	782	489

At the Metallurgical Plant

A certain metallurgical plant processes 10,000 tons of concentrates yielding three different metals. The production expenditures totaled: 8,100,000 rubles for raw material, and 1,500,000 rubles for metallurgical reduction. The related calculations are illustrated in Table 97.

Table 97

Calculating the Production Cost of Metals When the Raw Material /Concentrate/ is Processed Comprehensively

	Metal No. 1	Metal No. 2	Metal No. 3	Total
Content of metals in concentrates	50%	10%	40 grams/ton	-
Gross content of metals in 10,000 tons of concentrates	5,000 tons	1,000 tons	400 kg	-
Percentile recovery of metals at the plant	85	75	95	-
Quantity of obtained finished /ingot/ metals	4,250 tons	750 tons	380 kg	-
Purchase price of metals in concentrates, rubles	800	900	8000	-
Total value of metals in concentrates, thousands of rubles (5 x 2)	4000	900	3200	8100
Respective share of each metal in the value of raw material, percent	49.4	11.1	39.5	100.0
Expenditures on metallurgical reduction	741	166	593	1500
Percentile share of expenditures on metallurgical reduction	49.4	11.1	39.5	100.0

/Table 97 continued on next page/

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	Metal No. 1	Metal No. 2	Metal No. 3	Total
Total amount of expenditures on metals (6 8), thousands of rubles..................	4741	1066	3793	9600
Production cost per unit of obtained metals (10:4), rubles......................	1116	1422	9082	-

It follows from the above table that the production cost of the metals obtained as a result of comprehensive processing of the raw material is computed in the following manner:

(a) Determination of the quantity of metals contained in the raw material (e. g., metal No. 1 -- 5,000 tons) and the quantity of smelted out metals (metal No. 1 -- 4,250 tons);

(b) Calculation, on the basis of the purchase price of the in-raw-material metals, of the total expenditures on raw materials, amounting to 8,100,000 rubles (in which: on metal No. 1 -- 800 x 5,000 = 40,000,000 rubles /sic/;

(c) Determination of the share of each metal in the total cost of expenditures on raw material (metal No. 1 -- 49.4 percent; metal No. 2 -- 11.1 percent; and metal No. 3 -- 39.5 percent);

(d) Division, on the basis of these percentile shares, of the total amount of expenditures on metallurgical reduction (1,500,000 rubles) among the metals (with metal No. 1 accounting for 741,000 rubles);

(e) Summation of the expenditures on raw material and metallurgical reduction for each metal separately (4,000,000 + 741,000 = 4,741,000 rubles for metal No. 1);

(f) Division of the obtained numerical totals of expenditures by the number of the smelted out-metals, which is what yields the production cost per unit of each metal (for metal No. 1 -- 4,741 : 4,250 = 1,116 rubles).

To establish operative control over production cost of comprehensively processed materials, the cost of the metallurgical processing of one ton of raw material is adopted as the calculating unit.

In the example examined above the cost of processing one ton of concentrate amounts to 1,500,000:10,000 = 150 rubles.

3. Calculating the Reduction in the Production Cost of the Marketable Output of an Enterprise

The estimate calculations of individual types of products serve as the basis for calculating the over-all change in the production cost of the entire marketable output of the enterprise, on deducing the total percentage of reduction in production cost and the absolute-figure scale of the savings obtained from that reduction. This calculation is conducted in the following manner (Table 98):

Table 98

Calculating the Production Cost of Marketable Output

Type of Product	Output in Planned Year, Tons	Total Production Cost per Output Unit, rubles		Cost of Marketable Output in the Planned Year, thousands of rubles		Results	
		Reported	Planned	According to Reported Production Cost	According to Planned Production Cost	Total Savings, thousands of rubles	Percentage of Reduction in Production Cost
Metal	33250	2770	2440	92102	79800	-12302	-13.4
Marketable Concentrate	48240	170	160	8201	7718	-483	- 6
Total	-	-	-	100303	87518	-12785	-12.7

The nature of the above calculations is reduced to the following. The planned output of comparable marketable products is multiplied first by the actual total production cost per output unit in the preceding report year and, second, by the planned production cost of each type of product, and this is followed by summing up the cost of marketable output according to the reported and the planned production cost, whereupon these two totals are compared to deduce the over-all percentage of reduction in production cost for the entire volume of the comparable marketable output.

In addition to the percentage of reduction in production cost, the savings ensuing from this reduction are determined for the individual products and for the marketable output as a whole.

As for the non-comparable part of marketable output, it is determined in terms of planned production cost per unit of each product.

The mean percentage of change in production cost should also be calculated according to the calculational expenditure items, thereby deducing the summands of the change in production cost in the cross-section of the calculating blank.

The basis for every calculation is constituted by planned output calculated according to production cost (according to norms of consumption and prices in the preceding report year). The analysis of production expenditures according to separate expenditure items on the calculating sheet should lead to the same final result (same mean percentage of reduction and same total of savings) as was obtained in the foregoing calculation of production cost according to individual types of products.

The calculation could be illustrated by the following example (Table 99):

Table 99

Calculating the Savings According to Individual Elements of Production Cost

Element of Production Cost	Planned Output According to Production Cost of Preceding Report Year, thousands of rubles	Percentile Share of Expenditures	Index of Change	Percentile Result of change		Total Savings, thousands of rubles
				According to Expenditure Items	According to Total Production Cost	
Raw and basic materials	70212	70.0	0.87	60.9	-9.1	9 127
Fuel and electrical energy	7021	7.0	0.91	6.4	-0.6	602
Wages and allowances for blue-collar workers	6018	6.0	0.95	5.7	-0.3	301

/Table 99 continued on next page/

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Element of Production Cost	Planned Output According to Production Cost of Preceding Report Year, thousands of rubles	Percentile Share of Expenditures	Index of Change	Percentile Result of change According to Expenditure Items	Percentile Result of change According to Total Production Cost	Total Savings, thousands of rubles
Shop and plant-wide expenditures	15046	15.0	0.83	12.45	-2.55	2 554
Non-production expenditures	2006	2.0	0.90	1.8	-0.2	201
Total	100303	100.0	-	87.3	-12.7	12 785

The changes in the individual expenditure items are caused by the following factors.

Raw and Basic Materials

In connection with the increase in recovery indexes and intensification of the control of the consumption of materials, the quantitative consumption norms are reduced by eight percent (index of change: 0.92) and, in addition, as a result of a five-percent reduction in the cost of raw material (index of change: 0.95), the total index of change in this expenditure item amounts 0.92 0.95 = 0.87, i.e., the consumption norms decrease by 13 percent. At such an index of change the percentile share of this item will be expressed by the magnitude of 70· 0.87 = 60.9 percent.

The total reduction in production cost for this item will be 0.3 percent, and the related savings will be 301,000 rubles.

Shop and Plant-Wide Expenditures

At a 16-percent increase in output the absolute total

of shop and plant-wide expenditures for the planned year will decrease by four percent compared with the preceding year. Commensurately, the index of change in this item will be:

$$\frac{0.96}{1.16} = 0.83$$

and as a result the total production cost will decrease by a further 2.55 percent and the savings will reach 2,554,000 rubles.

Non-Production Expenditures

An analysis of the related expenditure items under this heading leads to a forecast of savings totaling 201,000 rubles for these items.

Thus, as a result of technical and economic analyses and calculations of changes in production expenditures it is established that the production cost of marketable output for the planned year should decline on the whole by 12.7 percent compared with the cost in the preceding report year, and yield savings totaling altogether 12,785,000 rubles. If the planned marketable output calculated according to the production cost in the preceding year amounts to 100,303,000 rubles then, on taking into account the stipulated reduction (12.7 percent) in production cost, it should actually cost 87,518,000 rubles to produce.

As a result of the 13-percent decrease in the expenditures on raw and basic materials, the production cost of the output as a whole decreased by $13 \cdot 0.7 = 9.1$ percent, which yields the following savings:

$$\frac{100.303 \cdot 9.1}{100} = 9{,}127{,}000 \text{ rubles}$$

Fuel and Electrical Energy

The utilization of the heat of waste gases and a number of other measures have made it possible to reduce the consumption indexes by an average of five percent, and the transition to local sources of fuel has cut the cost of fuel by four percent. Thus, the total index of change in this expenditure item amounted to: $0.95 \cdot 0.96 = 0.91$. The share of this item dropped to $7 \cdot 0.91 = 6.4$ percent, and in this connection the total production cost declined by 0.6 percent ($9 \cdot 0.07$), and the total savings in fuel-and-energy expenditures reached the magnitude of:

$$\frac{100,303 \cdot 0.6}{100} = 602,000 \text{ rubles.}$$

Wages of Blue-Collar Workers

Labor productivity in the planned year will rise 12 percent, but at the same time the wages also will rise, by seven percent, so that the index of change in this expenditure item will be:

$$\frac{1 \cdot 1.07}{1.12} = 0.95$$

4. Drafting the Over-all Estimate of Production /Expenditures7

The expenditures on the calculating blank are calculated according to shops, types of products and individual stage of the technological process and that blank serves as the principal document for an operative control of production. The calculations consist of simple and compound expenditures. The estimate of production /expenditures7 comprises the expenditures on the entire volume of output and it is compiled according to the primary elements of expenditures, upon the breakdown of the compound expenditure items into primary expenditures.

Primary elements of expenditures pertain to the expenditures which cannot be further subdivided within the confines of a given enterprise: (a) raw and basic materials; (b) fuel; (c) electrical energy; (d) basic and additional wage; (e) fringe benefits; (f) amortization; (g) miscellaneous expenditures. A compound expenditure is a complex expenditure item consisting of a number of individual expenditure elements. Compound expenditures pertain to: maintenance and repair of equipment; shop overhead expenditures; plant-wide expenditures.

The breakdown of compound expenditures into primary expenditure elements can be illustrated by the following nominal example (Table 100).

Inasmuch as compound items can be broken down into primary expenditure elements, the division of expenditures into basic and overhead ones is not employed in the estimate of production and instead a rigorous distinction is made between the purchased materials and the materials fabricated by the enterprise itself. For instance, if the enterprise receives its ore or concentrates from the outside, the related expenditures will be recorded in the "Raw Materials"

item of the estimate of production, but if the enterprise extracts its own raw material, then the expenditures on the extraction of the raw material will be recorded in the appropriate expenditure elements ("Wages," "Energy," "Materials," etc.) of the estimate of production. The same principle applies to all other types of materials, fuel and energy.

Table 100

Breakdown of Compound Expenditures Into Primary Expenditure Elements

Compound Expenditures	Total Amount, thousands of rubles	In which: by Expenditure Element (in thousands of rubles)					Miscellaneous Expenditures
		Materials	Fuel	Electrical Energy	Wages and Allowances	Amortization	
Shop overhead expenditures	1100	300	150	120	400	80	50
Plant-wide expenditures	400	50	40	30	160	40	80
Total	1500	350	190	150	560	120	130

The wage expenditures in the estimate of production comprise the total fund of basic and additional wages for every employee in the industrial-production category (blue-collar workers, white-collar workers, engineers, technicians, maintenance personnel).

The "Amortization" item takes into account the amortization deductions for all types of shop and plant-wide property (except for residential real estate).

The "Miscellaneous Expenditures" item includes all types of financial expenditures involved in the payment of taxes, fees, postage, etc.

Depending on the organizational structure of an enterprise the relationship among the individual expenditure elements in the estimate of production may be sharply different percentagewise. Thus, e. g., at a mining-metallurgical combine processing its own raw material and fuel, the material expenditures will account for a much lower share in the

estimate of production /expenditures/ than at an enterprise receiving its raw materials and fuel from the outside.

The estimate of production /expenditures/ is a very responsible document in the system of the industrial-financial plan of an enterprise, as it serves as the point of departure for drafting the plan of material supplies and the financial plan of the enterprise.

The cardinal characteristics of the estimate of production /expenditures/ are as follows:

(a) The estimate of production /expenditures/ represents the totality of the expenditures calculated for the entire volume of the produced output.

(b) Production outlays in the estimate are cited in the cross-section of primary elementary expenditures (without subdivision into basic and overhead production expenditures);

(c) The estimate of production /expenditures/ encompasses not only the cost of marketable output but also the cost of the processed semifinished products and the change in the inventory of uncompleted production;

(d) To determine the cost of marketable output it is necessary to deduct from the total of the estimate of production /expenditures/ the increment in semifinished products and uncompleted production (if their inventory increases at the end of the year) or conversely to add this increment (if their inventory decreases at the end of the year).

The approximate form and structure of the estimate of production /expenditures/ of an enterprise is reproduced as follows (Table 101):

Table 101

Expenditures for the Planned Period, Excluding Intra-Plant Turnover

	Total Amount in thousands of rubles
Raw Material (Ore)	51,380
Basic and Auxiliary Materials	9,200
Fuel	2,400
Electrical Energy	5,000
Basic and Additional Wages	12,006
Fringe Benefits	1,092
Amortization	2,325
Miscellaneous (Financial) Expenditures	2,474
Total Expenditures, According to Plant-Wide Production Cost	85,877

To determine the cost of marketable output from the above, it is necessary to take into account:

(a) Expenditures involved in an increment in uncompleted production	--664
(b) Cost of semifinished products utilized from their inventory in the planned year	+500
Total, Plant Production Cost of Marketable Output	85,713
Non-Production Expenditures	1,805
Total (Commercial) Production Cost of Marketable Output	87,518

To illustrate the methods of composing an estimate of production expenditures, let us clarify briefly the principal expenditure elements.

Raw Materials. During the planned year, the enterprise will process 1,400,000 tons of ore containing a gross total of 38,350 tons of copper and 30,150 tons of zinc. When the purchase price for the in-ore copper amounts to 10 rubles a ton-percent or 1,000 rubles a ton, and the price for zinc -- two rubles a ton-percent or 200 rubles a ton, then the total cost of the in-raw-material metals will be:

$$(1{,}000 \cdot 38{,}350) + (200 \cdot 30{,}150) = 44{,}380{,}000 \text{ rubles.}$$

Assuming the cost of the transport and unloading of ore amounts to five rubles per ton or 7,000,000 rubles for the entire tonnage, we find that the total cost of raw material amounts to 51,380,000 rubles.

Electrical Energy. On the basis of the unit consumption rate of 30 kwh of electrical energy per ton of ore during its beneficiation, we find the total consumption of energy at the concentrator plant:

$$30 \cdot 1{,}400{,}000 = 42{,}000{,}000 \text{ kwh.}$$

At the metallurgical plant, where the index of consumption of electrical energy per ton of metal amounts to 540 kwh, and where the annual output of metal totals 33,250 tons, the total consumption of energy will be:

$$540 \cdot 33{,}250 = 17{,}955{,}000 \text{ kwh.}$$

Taking into account the consumption of electrical

energy on illumination and other needs of the enterprise (11,495,000 kwh) the over-all total demand for electrical energy will amount to 71,450,000 kwh, which, at the price of seven kopeykas per kwh, will equal 5,000,000 rubles.

Fuel and Materials. The cost of these expenditures is determined on the basis of the indexes of their consumption per product unit and the production targets established for the shops.

Exemplary Calculation of Expenditures on the "Heating" Item*

$$v = \frac{1 \cdot (t_1 - t_2) \cdot r \cdot n \cdot c}{1{,}000}$$

where v is total amount of expenditures on heating;
1 is cubic space of premises (32,000 m3);
t_1 is inside temperature (+16°C);
t_2 is outside (mean) temperature (-3.7°C);
r is consumption of nominal fuel per m^3 of premises to heat the latter (0.0012 kg per Centigrade degree);
n is number of heating days in the year (193);
c is cost per ton of nominal fuel (120 rubles)

$$v = \frac{32{,}000\ [16-(-3.7)] \cdot 0.0012 \cdot 193 \cdot 120}{1{,}000} = 17{,}520 \text{ rubles}$$

Wages and Fringe Benefits. The heading "Planning of Labor and Wages" contains figures on the total wage fund of the enterprise (12,006,000 rubles), and it is this sum that has been included in the estimate of production expenditures. Fringe benefits are stipulated on the scale of 9.1 percent of the wage fund.

Amortization. When the mean annual value of the assets of the enterprise amounts to 46,500,000 rubles and the mean rate of amortization deductions is five percent, the total amount of [yearly] amortization is determined at 2,325,000 rubles.

The correctness of the compiled estimate of production [expenditures] is verified by comparing the sum total of

*Taken from "Examples and Visual Aids for the Course in 'Organization and Planning of Production," Central Administration for Statistical Survey of Planning of the National Economy, Gosplan USSR, 1940.

expenditures with the cost of marketable output. Thus, in our example, on deducting the 664,000 rubles of expenditures relating to the increment in uncompleted production and adding the 500,000 rubles of the cost of semifinished products inventory transferred from the preceding year, we obtain the plant production cost, and hence the total production cost, of marketable output in the same figures as those in which it was determined in the calculation of the reduction of the enterprise's production cost (87,518,000 rubles).

5. Intra-Branch Prices of Raw Materials, Semifinished Products and Production Wastes

The delivery of ore raw materials and the transfer of semifinished products and production wastes from one enterprise to another in nonferrous metallurgy are conducted on the basis of established intra-branch prices for raw materials, semifinished products and production wastes.

These prices are based on the sales prices of the finished metals and on the expenditures needed to process the raw material or semifinished product into a finished product. The longer the technological path and the more expenditures are involved in this processing the relatively lower will be the pricing of the metal in the raw material or in the semifinished product.

The system of intra-branch prices has a distinguishing feature: in it, the prices are established not for the ore nor for the semifinished products nor for the production wastes but for the valuable components they contain.

The prices for raw materials and semifinished products may vary strongly in direct proportion to the percentile content of metals. The unit for which a price is established is constituted by the percentage of the content of metal in one ton of raw material or semifinished product ("ton-percent") or by one gram of a precious metal contained in an ore material ("gram-ton"). Thus, when the price per ton-percent is eight rubles, the cost of one ton of ore containing 1.5 percent of metal will be 12 rubles, and if the same kind of ore contains five percent of metal, then its cost will be 40 rubles. The pricing pertains not to any one single metal but to all the valuable components that can be usefully recovered during the processing of metal-containing materials. In a polymetal ore, the pricing pertains to the industrially recoverable lead, zinc, gold, and silver it contains.

The determination of the cost of semifinished products

is based only on the usefully recovered components which do not constitute a deletorious impurity in a given semifinished product. A metal which during beneficiation passes into the concentrate of another metal (e. g., zinc in the copper concentrate) is not considered as a usefully recovered component, and therefore it is not included in the price.

Thus, the cost of one ton of a metal-containing material depends on: number of useful components, percentile content of these components in the material, and the concrete price per ton-percent of each metal.

To improve the quality of output, the system of intra-branch prices is geared to provide incentives -- cuts in and bonuses to basic prices, or differentiation of prices according to the quality (content of metals) of the raw material.

Thus, e. g., the overfulfillment of the plan of the content of metals in ore is rewarded by raising by 50 kopeykas the price per ton of ore for every 0.1 percent increment in excess of the plan (or five rubles for every whole additional percent in excess of the plan) and conversely, the underfulfillment of that plan is penalized by cutting the price in the same proportions. If the content of metal in ore is planned to amount to two percent for the planned year but actually it is later found to amount to 2.3 percent, then the cost per ton of ore will be: basic price 82.3 = 18.4 rubles plus (50-kopeyka) bonus -- 0.3 = 1.5 rubles, or altogether 19.9 rubles.

When differentiated prices are used, the cost per ton-percent varies depending on the content of metal in a semifinished product.

For instance, the price per ton-percent of a metal in a concentrate, and hence also the cost of the concentrate itself, may vary in the following manner:

Content of Metal percent	Price per ton-percent rubles--kopeykas	Cost of One Ton of Concentrate, rubles
40-45	3.00	120-135
47	4.00	188
50	5.00	250
55	8.00	440

It follows from the above figures that the cost of a concentrate is determined not only by its content of metal but also by the varying price for the metal in the concentrate. At a 40-45 percent content the cost of one ton of

in-concentrate metal amounts to 300 rubles, while at a 50-percent content this cost amounts to 500 rubles.

The higher prices which the user-plant has to pay for the concentrate with a high content of metal are compensated, first, by the fact that the use of a high-quality concentrate improves substantially the recovery and increases the output of metal at the user-plant and, second, by the decrease in expenditures on processing and by the savings in transport expenditures when hauling metal-rich concentrates.

One of the cardinal principles in determining intra-branch prices is to ensure a profitable operation of all the links of the system of the concerned branch of industry. While the sales price for the finished [ingot, bullion] metal remains one and the same, the intra-branch links could be so organized that either all profits would accumulate in some one single link or, conversely, so that the profits could be distributed among all the enterprises related by a single technological process.

Let us assume that three independent production units (an ore-mining enterprise, a concentrator plant and a metallurgical plant) together produce a metal whose production cost is 2,600 rubles a ton and sales price in bullion form -- 3,000 rubles a ton. Now let us consider two versions of distribution of profits among these three enterprises.

Distribution of Profits per Ton of Metal

	Production Expenditures	Sales Price per ton, rubles	Profit
First Version			
1. Ore-Mining Enterprise			
Ore Extraction................	800	800	-
2. Concentrator Plant			
Raw Material--800.............	-	-	-
Processing--1,200.............	2,000	2,000	-
3. Metallurgical Plant			
Raw Material--2,000...........	-	-	-
Processing--600...............	2,600	3,000	+400
Second Version			
1. Ore-Mining Enterprise			
Ore Extraction................	800	900	+100

[Table continued on next page]

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	Production Expenditures	Sales Price per ton, rubles	Profit
2. Concentrator Plant Raw Material--900 Processing--1,200	2,100	2,250	+150
3. Metallurgical Plant Raw Material--2,250 Processing--600	2,850	3,000	+150

In the above example [in the first version] as we can see, the ore-mining enterprise and the concentrator plant sell their output according to intra-branch prices -- prices equal to their production costs -- and the entire difference of 400 rubles between the total production expenditures and the sales price is realized by the metallurgical plant only. Such a construction of intra-branch prices for ore and concentrates would be inherently faulty.

The second version contains the same indexes of processing costs and the same final price for the finished metal as in the first version, but here the intra-branch prices for ore and concentrates are such that the 400-ruble profit is distributed among all three enterprises: 100 rubles goes to the ore mine, 150 rubles goes to the concentrator plant, and 150 rubles goes to the metallurgical plant. The second version is the correct one, because in this case the profitable operation of every link is assured.

Of course, the decisive factor in achieving profit in every branch of industry is the reduction of production cost, but the profitability of operation of every individual enterprise also hinges greatly on a properly constructed system of intra-branch prices.

END